Study Report 99-01

Use and Management of Digital Information by Army Aviation Battalion Battle Staff Members

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14. ABSTRACT *(Maximum 200 words)*: This report is based on empirical research embedded within a training simulation exercise. Brigade and battalion tactical operations centers were replicated with partial implementations of the Army Tactical Command and Control System digitized suite. The brigade installation served as a control center. Observational data were compiled from events and activities in the battalion installation. Over a five-day period a student battalion battle staff conducted mission planning and execution functions within an operational scenario presented through a confederation of computer based simulation systems. Observers recorded events during mission planning, execution and after-action reviews. The student battle staff members completed questionnaires covering background and experience prior to the exercise, activities and experiences during mission planning, and a questionnaire seeking their impressions of potential training effectiveness. Key staff members were interviewed during the week following the exercise. Findings address tactics, techniques, and procedures for utilizing digital command and control systems in the military decision making process and the decision support template and recommend information display configurations.

15. SUBJECT TERMS

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FOREWORD

The primary goal of the 21st Century Army, Force XXI, is to optimize capabilities through information technology. Organization centered on weapon systems will give way to organization centered on information exchange that leads to unified action. Force XXI will dominate, control and win through an information-based battle command structure that functions with greater adaptability, fluidity and decisiveness than has ever been seen before. The Army is being redesigned for the information age by defining its doctrine, training, leaders, organization, materiel and soldiers according to knowledge gained from experimentation carried out through the Battle Lab process, Advanced Technology Demonstrations and Advanced Warfighting Experiments.

Alterations made to introduce new technologies that provide increased generation and transmission of data will not, alone, enable the Army to reach its goal. Data are not information, information is not knowledge, knowledge is not wisdom. Information technology, in the form of hardware and software that generate, manage and display information for a command staff may provide an orderly and rapid presentation of relevant information and therefore provide the command staff more time to deliberate its course of action. It can not provide that staff with ready made judgment or qualitative evaluation. The hardware and software can not think for them. To reach its goal the Army must devise a command structure that considers the staff and its digital decision aids as an integrated system.

This report provides an analysis of the behavior of a command staff in a digitized, simulated operational environment and presents recommendations for the design of those decision aids and the training that will be required to achieve efficient operation of that integrated command system. The report also provides recommendations for the methodologies needed to perform the behavioral research necessary to continue the redesign process. The results of this work are relevant to policy, doctrine and training program decisions.

Results and findings from this research were briefed to COL William Powell, Director of Training Doctrine and Simulation, U.S. Army Aviation Center, COL Gary Coleman, Deputy Director, Air Maneuver Battle Lab and COL Russell Forshag, Director, Warfighting Futures Division, Directorate of Training Doctrine and Simulation, on March 4, 1998. Results and findings were briefed to LTG William Bolt, Deputy Chief of Staff for Training, and to MG Daniel Petrosky, Commander, U.S. Aviation Center and Fort Rucker, on March 5, 1998. Results and findings were briefed to LTG Montgomery Meigs, Commander, Combined Arms Center, on March 24, 1998.

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USE AND MANAGEMENT OF DIGITAL INFORMATION BY ARMY AVIATION BATTALION BATTLE STAFF MEMBERS

EXECUTIVE SUMMARY

Research Requirement:

This report results from a set of requirements submitted to the U.S. Army Research Institute for the Behavioral and Social Sciences 1998 Research-Based Personnel and Training Study and Analysis Program by the Directorate of Training, Doctrine, and Simulation, U.S. Army Aviation Center at Fort Rucker, Alabama. This work has been carried out as part of Work Package 2151: Force XXI Aviation Battle Staff Training: Integration of C4I Into Battle Simulation and has been produced through the cooperative efforts of the Army Research Institute and the U.S. Army Aviation Center.

The requirements statement listed five requirements, four of which are addressed in the research reported here: 1. develop baseline tactics, techniques, and procedures for utilizing digital Command, Control, Communications, Computers and Intelligence systems to perform the military decision making process, 2. develop baseline tactics, techniques and procedures for monitoring execution of the decision support template utilizing digital systems, 3. develop a recommended display configuration which best supports the commander's information requirements and 4. determine whether an information manager is required in the digital tactical operations center and who that person should be.

Procedure:

This effort is based on empirical, nonexperimental research embedded within a training simulation exercise that constituted the capstone event of staff officer training for the Aviation branch. Time and resources were insufficient to permit an experimental approach nor would experimentation be efficient given the objectives that resulted from the requirements.

The study was conducted in the Army Aviation Test Bed and the Aviation Warfighting Simulation Center, interconnected within a fiber optic cable network. Both facilities are reconfigurable simulation centers that support a wide range of Army aviation research. Brigade and battalion tactical operations centers were replicated in these centers with partial implementations of the Army Tactical Command and Control System digitized suite. The brigade installation served as a control center. Observational data were compiled from events and activities in the battalion installation. Each tactical operations center had three cells: a current operations cell, a plans cell, plus an administrative and logistics operation center.

Over a five-day period a student battalion battle staff conducted mission planning and execution functions within an operational scenario presented in a virtual simulation that was implemented by a confederation of computer based operational and tactical simulation models. Battalion operations were conducted in response to orders issued by the simulated brigade staff. These components simulated both friendly and enemy maneuver forces. A ten member observer staff recorded events during mission planning, execution and during after action reviews according to formats established to address issues relevant to the requirements and objectives. The student battle staff members completed questionnaires covering their background and experience prior to the exercise, their activities and experiences during mission planning, and a questionnaire pertaining to their impressions relating to training potential effectiveness. Five key staff members were interviewed during the week following the exercise.

Findings:

Despite the constraints in the design of the exercise, this study yielded useful information about problems that can be solved by developing new tactics, techniques and procedures and the general descriptive information concerning them. Problems with planning time and distribution of planning tasks among members of the battle staff indicate a need for more formalized workload distribution and time management under both normal and time constrained conditions with an emphasis on tailoring planning activities to available time. There is also a need to specify planning activities that can be carried out concurrently. An implication of this is a need for increased cross training among the incumbents of staff positions.

There is a need to specify the manner in which each digital subsystem of the digitized suite should be used to accomplish each mission-planning step. Emphasis should be placed on the unique capabilities of each subsystem and efficient transfer of data among them. There is also a need for improved management of graphic information, particularly the origins and ages of icons and control measures. This study provided no evidence that adding an information manager to the battle staff is the best way to improve the management of information. This problem would be better addressed by governing the information management activities and responsibilities of existing battle staff members. Specific areas of opportunity include distribution of information monitoring activities, screening incoming information, and anticipation of information needs

This study yielded no specific information about the problems that battle staff members encounter when monitoring the execution of a decision support template. Other information gained from the study can be used to address general requirements to remediate problems with the decision support template that are likely to be encountered. Battle staff procedures should minimize the requirements for battle staff members to remember the location of decision points and trigger events, possibly through special graphic overlay that depicts the template. The responsibility for monitoring the execution of decision support templates should be shared by two or more battle staff members. The workload for this should be integrated into their other tasks to prevent overload.

In addition, there appears to be a need to ensure that all information from prior missions is removed from the digital systems, ensure that all echelons employ a common file-naming date-time label protocols, and ensure that all files transferred among systems or echelons are accompanied by a free text message describing their contents.

There is a need to govern the use and implementation of pull-down menus to prevent obscuration of map information while a menu is in use. In addition, battle staff members need a more direct method for scrolling within a map display and changing the level of map magnification. There were many instances in which battle staff members were unable to discriminate important information that was portrayed on the large-format wall mounted display. Inspection revealed that alphanumeric and point symbols were depicted with too few raster lines, inadequate height or inadequate figure-ground contrast. Control measure symbology often obscured map detail. Three approaches to reducing the severity of obscuration are suggested. One is simply to reduce the area covered by symbols. The amount that symbol size can be reduced and still be easily legible depends on the factors that influence display resolution. A second approach is to color symbols rather than shape code them. A third approach is to provide a capability to temporarily remove symbols that obscure important map detail. Ideally, the digital systems would be programmed to enable operators to temporarily remove a single symbol, all symbols of a specified class, or all symbolic information depicted.

There is a need to coordinate the level of map detail with the displayed map magnification. This implies software that selects classes of topographic features and changes the rules of topographic feature generalization depending on the size of the area portrayed. Alternatively, key battle staff members might be provided with duplicate displays except for topographic database scale. This solution may increase the requirements for equipment, space, and personnel, but is technically feasible at the present time.

Regimental icons commonly used to depict the locations of enemy forces are not adequate in some situations. Display systems should enable battle staff members to deaggregate the icons to the company level. The effectiveness of tracking and display of friendly aircraft locations would be improved with identification tags attached to the their display icons. There is a need to modify threat icons to depict the age of the intelligence information underlying it. The color, shape, or brightness of a threat icon could be changed systematically to reflect its age. Likewise, threat icons should indicate their condition as active or destroyed.

The study also yielded lessons about the methodology. In future studies of this type, every attempt should be made to acquire the time and resources needed to provide battle staff members with comprehensive training on the functions and operation of the digital systems. Instructional utility may be improved by increasing the volume of intelligence information that must be processed during mission planning and during mission execution. The comparatively low volume of intelligence traffic in this exercise caused the workload of some battle staff members to be unrealistically low.

In future studies of this type, consideration should be given to face-to-face interviews with individual battle staff members as a means of obtaining detailed information about mission planning problems and oversights. Some mission planning problems and oversights do not become apparent until after the mission has been executed. Interviews to identify specific mission planning problems and oversights are likely to be most effective if they are conducted immediately after the mission has been executed.

A nonexperimental study may not be the most effective way to define tactics, techniques and procedures. Even with a fully proficient battle staff this study could have yielded information only about the tactics, techniques and procedures that were used. Optimization of tactics, techniques and procedures will more likely result from an experimental approach in which performance is measured as the alternatives are varied systematically.

The present study indicates that the amount of time required to perform the planning steps, individually or collectively, is not a reliable measure of the proficiency of the battle staff members who perform them. Perhaps the most important factor is the tendency of a battle staff to use all of the planning time that is available. Another factor is that the characteristics of the mission have an enormous influence in the amount of time that is required to plan the mission.

Additional training of observers is needed to improve their ability to recognize key events and problems that occur during mission execution. For example, additional training probably would increase observers' ability to recognize and record key decision points and instances of heavy workload. However, it seems unlikely that additional training would significantly improve observers' ability to recognize decision errors, problems encountered in operating the digital equipment, and problems encountered in interpreting the digital system displays.

Passive observation by relatively inexperienced observers can yield a great deal of useful information about activities and problems that occur during mission execution. However, there are ways to improve the information that is recorded by the observers. One way is to replace the voice communication system used in this study with a system in which headphones rather than speakers are used. With speakers, it is impossible for observers to track the flow of information to and from each battle staff member. That is, it is impossible for observers to determine the battle staff members who hear messages that are announced over the speakers.

Analysis of voice communication events yields valuable information about information management problems, the absolute and relative workload of battle staff members, and command style. Although very labor intensive, the recording and analysis of communication events is highly recommended for future research on the use of digital command and control systems. Development of automated systems to facilitate this by reducing labor and processing time is a recommended. Automation of communication event recording and analysis could also provide enhanced training.

Utilization of Findings:

These findings are provided to the U.S. Army Aviation Center and other Training and Doctrine Command centers to facilitate policy, doctrine and training program decisions. They pertain to the design and development of improved digitized battle staff equipment and organization, establishment of training requirements for duty in brigade and battalion staff positions, design and development of staff training programs and to the design of future research involving group interactions in medium and large scale human-computer systems.

USE AND MANAGEMENT OF DIGITAL INFORMATION BY ARMY AVIATION BATTALION BATTLE STAFF MEMBERS

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Introduction

Background

Requirements

The impetus for this study was a set of requirements issued by the Directorate of Training, Doctrine, and Simulation (DOTDS), U.S. Army Aviation Center (USAAVNC), Fort Rucker, AL. A DOTDS requirements statement, dated 30 January 1997, listed the five requirements shown below.

- Develop a plan for the integration of digital Command, Control, Communications, Computers and Intelligence (C^4I) systems into aviation leader training.
- Develop baseline tactics, techniques, and procedures (TTPs) for utilizing digital C^4I systems to perform the military decision making process (MDMP).
- Develop baseline TTPs for monitoring execution of the decision support template (DST) utilizing digital C^4I systems.
- Develop a recommended C^4I system display configuration which best supports the commander's information requirements.
- Determine whether an information manager is required in the digital tactical operations center (TOC) and who that person should be.

These requirements were submitted to the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) 1998 Research-Based Personnel and Training Study and Analysis Program as a result of the USAAVNC response to a request from the Training and Doctrine Command (TRADOC) for input to the Office of the Deputy Chief of Staff for Training (ODCST) study requirements. The objective of the Study and Analysis Program is to conduct rapid turn-around investigations in support of Army policy and doctrine. Studies conducted within this program typically use behavioral and social science knowledge and expertise plus existing data bases to provide information for policy and doctrine decisions. The request submitted by the USAAVNC was selected and entered into the program as Work Package 2151: Force XXI Aviation Battle Staff Training: Integration of C4I into Battle Simulation. The work reported here results from a cooperative effort among ARI, USAAVNC DOTDS, the 1st Aviation Brigade, the Directorate of Combat Developments (DCD) and the Air Maneuver Battle Lab (AMBL) as principle parties.

The efforts reported here were designed to address all of the above requirements except the first. The first requirement will be met through nonempirical methods (e.g., review of relevant literature, interviews with subject matter experts (SMEs) and reported in a separate document.

The Army Battle Command System

The cornerstone of the Army's plan to meet the challenges of the 21st Century is the development of the capability to achieve information dominance on the battlefield. The achievement of information dominance requires the means to (a) destroy, disrupt, and control the enemy's capability to compile and distribute information and (b) provide our commanders with accurate, relevant information quickly enough for them to use it effectively. The Army has a plan for development and introduction of digitized systems into the command structure to help achieve this condition.

ABCS. This plan organizes digitization efforts around the force structure and levels of command. Digitally equipped TOCs are included for echelons above corps (EAC) and at corps, division, brigade and battalion levels with additional digitization capabilities applied below the battalion level. At each level a suite of computer based automated applications operates within a local area net interconnected to other nets at levels above, below and parallel within the command structure. At the apex is the Army Battle Command System (ABCS) which comprises the Global Command and Control System-Army (GCCS-A) for strategic, theater and EAC applications, the Army Tactical Command and Control System (ATCCS), which applies to corps through battalion levels, and the Force XXI Battle Command Brigade and Below (FBCB2) system which represents the evolution of a system known as Appliqué.

The GCCS-A is intended to facilitate force tracking, support for conducting civilian affairs and host nation coordination, theater air defense, targeting, psychological operations, command and control, logistics plus medical and personnel status support. It provides a standard format and method for worldwide theater command and control, combat service support for EAC, facilities for planning and execution of mobilization, deployment and sustainment, and supports joint, combined, and allied operations in addition to special operations and operations other than war.

The ATCCS comprises five main subsystems plus four supporting subsystems. The five main subsystems are the Maneuver Control System (MCS), All Source Analysis System (ASAS), Advanced Field Artillery Tactical Data System (AFATDS), Air and Missile Defense Workstation (AMDW/S) and Combat Service Support Control System (CSSCS). The four supporting subsystems are the Integrated Meteorological System (IMETS), Digital Topographical Support System (DTSS), Common Ground Station (CGS) and Battlefield Planning / Visualization (BPV) system.

The FBCB2 is intended primarily for installation on individual vehicles although it may be found in TOCs. It provides integrated battle command capability to commanders at all levels from brigade down. It integrates internal capabilities of weapon and sensor systems for generating and processing information with parallel systems and information nodes above and below. FBCB2 provides near real time display of friendly unit locations, reported enemy and unidentified unit locations, spot reports, calls for fire, environmental hazard reports (nuclear and biological contamination) and medical evacuation requests. FBCB2 also facilitates creation and dissemination of operational orders and tactical overlays plus logistics and personnel reports.

The ABCS is designed around the requirement for interoperability among nodes and levels. This is accomplished primarily through a suite of communications devices with a high degree of commonality throughout the system. These devices include Mobile Subscriber Equipment (MSE), generally present at brigade and above command nodes, an Integrated Network Controller (INC) which manages message traffic through routing functions, the Enhanced Position Location Reporting System (EPLRS), a digital radio system with integrated automatic position information, complex security measures and traffic conflict resolution, the Single Channel Ground Air Radio System (SINCGARS), which handles voice and digital communication in a prioritized mode, the Near Term Digital Radio (NTDR), which is intended as a backbone data exchange channel with reduced cost and increased capacity, and the Battlefield Awareness Data Dissemination (BADD) System, which utilizes satellite relay capabilities to broadcast a broad array of graphic and text based information to receiving workstations at all levels. All of the communications devices are interfaced on the Tactical Internet, a wireless wide area network. The ABCS is an evolving system with changes in the number and type of subsystems, changes within subsystem and changes to network configurations occurring commonly.

ATCCS. The most familiar, common and mature of the ATCCS main subsystems is MCS. The MCS provides a facility with which corps through battalion commanders and their staffs can collect, coordinate and evaluate near real time battlefield information, mostly through graphic representations on a plan view display. MCS establishes a common picture of enemy and friendly unit locations, distributes battle plans and orders, provides a facility for collaborative planning and displays unit personnel and logistic status in support of resource management functions. MCS is centered on a terrain relief map display with corps (and lower) graphic control measures plus icon representations of own force and opposition unit locations. Dissemination of plans and operational orders (OPORDs) uses web site architecture and a common word processing environment (MS-Word) with document templates. MCS supports generation of execution synchronization matrices. Collaborative planning is aided through interactive graphic input and a live audio channel, anticipating geographic dispersion of units (e.g. a battalion may be separated from its brigade TOC by as much as 80 kilometers). Inclusion of personnel and logistics status appears to overlap the CSSCS functions, however, this anticipates separation of Administrative and Logistics Operations Center (ALOC) from the maneuver TOC. MCS will be located with corps, division command staffs, corps signal battalion, division artillery, mobile and airborne command vehicles, and at brigade, battalion, and squadron TOCs.

The ASAS Remote Workstation (RWS) is intended to display a combination of analyzed combat intelligence and raw combat information. It provides situational awareness with regard to enemy disposition by integrating multiple information sources at varying levels of refinement including intelligence assessments, processed imagery, raw sensor feeds and battlefield reports. Processed imagery may be taken from national, theater and tactical sources. Raw sensor sources may include, for example, unmanned aerial vehicles (UAV) and the Joint Surveillance Target Attack Radar System (JSTARS). ASAS provides database facilities to aid data collection, data management and application of data to performance of Intelligence Preparation of the Battlefield (IPB) functions. In addition, the ASAS is the intelligence and electronic warfare (IEW) element of the ATCCS.

AFATDS is designed for the C^4I requirements of fire support functions. These include Army and other service missile, rocket, cannon, and mortar type weapons plus close air support (CAS) fires. AFATDS uses command guidance, weapon availability and target type to match targets to optimal weapons, coordinates fire support missions through distributed messages, maps and control graphics. This system receives message and sensor information from Army, Marine and Air Force ground based systems. Planning tools for route selection, course of action analysis and fire mission planing are integrated.

The AMDW/S generates graphic displays of weapon and sensor locations, provides a means for altering map graphics, and facilitates detailed terrain analysis. particularly for line of site determination, and monitors mission progress in near-real time. AMDW/S supports the development of air defense artillery (ADA) missions. For Air Battle Management (ABM), the AMDW/S provides the capability to display air control orders, current fire unit status, alert posture, and missile expenditure. It is notable that AMDW/S uses true digitized map displays, unlike the other ATCCS main subsystems which use raster scanned images of printed maps. It is also notable that AMDW/S would not normally be located in a maneuver battalion TOC. The major thrust of AMDW/S is air defense mission planning and coordination. It also provides an early strike warning system for theater ballistic missile attack, including launch and impact points. AMDW/S also provides visual and auditory warning of approaching enemy aircraft and automated slew of designated defensive systems to counter the highest threat.

The CSSCS is a status reporting facility to aid decision making and planning logistic support of combat operations. CSSCS provides resource status summary displays, a course of action analysis aid and correlates supply requirements with task organization down to company level. CSSCS tracks the Commander's Tracked Items List (CTIL), a subset of the Baseline Resource Items List (BRIL). CSSCS is partially integrated with the more common Standard Army Management Information System (STAMIS) but does not recognize units below company level. The CSSCS is not normally resident in a battalion TOC.

There is one other main subsystem to ATCCS which is not generally presented as part of the suite. This is the Forward-Area Air Defense Command, Control and Intelligence ($FAADC^2I$) system. Properly, $FAADC^2I$ includes a $FAADC^2$ computer and software plus associated sensors. The $FAADC^2I$ provides automated display of targeting data to air defense systems for rapid threat reaction and air battle management in either engagement operations (EO) or force operations (FO). Hence, a $FAADC^2I$ terminal may be referred to as FAADEO. FAADEO properly refers to the information provided to fire units and the procedures used to execute engagements (i.e. targeting). FAADFO properly refers to air defense related unit locations and battlefield geometry information. The functions of $FAADC^2I$ are similar to AMDW/S with less integration of radar based information.

The IMETS is a supporting subsystem of ATCCS that provides current and predictive meteorological reports and weather effects including low level winds at specified locations. IMETS delivers graphic weather overlays to MCS maps and incorporates the Integrated Weather Effects Decision Aid (IWEDA) for prediction of weather effects on weapon systems. The DTSS is an automated terrain analysis and reproduction system for decision support through terrain.

visualization and IPB. DTSS produces hard copy color maps and digitally stored map images and a large format scanner for importing nonstandard maps. The CGS is designed to acquire, display and disseminate data from multiple sensors such as JSTARS, U-2, UAVs and Guardrail. It provides real-time display of visual imagery from sensors operating in a variety of electromagnetic spectrum bands, as well as signal and electronic intelligence acquisition products. Displays are overlaid on digital maps and can provide automated monitoring of specific areas of interest. The BPV system provides animated course of action analysis, wargaming, planning, IPB and mission rehearsal capabilities. It is planned for integration into MCS. BPV animates panned and predicted unit movements in a three-dimensional terrain model using task organization and friendly unit locations generated by MCS and enemy unit locations generated by ASAS. These supporting subsystems are not normally resident at echelons below brigade.

ATCCS accomplishes interoperability through application of client-server architecture interfaced by means of a web browser facility (Netscape) and transfers data in United States Message Text Format (USMTF) and/or the File Transfer Protocol (FTP). The client-server architecture is not yet fully supported (e.g. AMDW/S does not support client access). ATCCS, like ABCS, is an evolving system with changes in the number and types of subsystems, degree of integration, subsystem features network configurations occurring commonly. These changes are intended to increase the utility of ATCCS within each of the five BFAs addressed . The brief descriptions presented here are, to the best of the authors' ability, accurate representations of the functions and organization of the ABCS and ATCCS at the time this study was conducted.

Training Needed to Achieve Information Dominance

Digitization of the functions and processes of battle staff planning and mission execution is expected to provide significant enhancements to situational awareness, reduced mission planning time, enhancements to tactical decision processes and improved execution synchronization. Increased situational awareness on the part of the commander and staff is expected to improve command and control through precision, flexibility and resource management. The planning process is expected to benefit from exact duplication of information and guidance at every command level with reduced human error and earlier dissemination of information required for planning. Digitally formatted spot reports and battle damage assessment are expected to be broadcast over secure networks simultaneously to all prospective consumers resulting in greater precision and timelines.

Although the ATCCS systems have vastly increased the amount and currency of relevant information that is available to a commander and his staff, it cannot be assumed that the increased volume of information will translate into corresponding improvements in either the planning or the execution of battlefield operations. Such improvements can be realized only if two requirements are met. First, members of the battle staff must be fully knowledgeable about the capabilities of each ATCCS subsystem and must be skilled in using each system to plan and control battlefield operations. Second, members of the battle staff must have sufficient information management skills to avoid becoming overloaded by the vast variety and volume of information that can flow from the ATCCS systems.

Training on the functions and operation of each of the ATCCS subsystems is necessary but not sufficient to ensure information dominance. Battle staff members also must receive two types of training on the collective use of the ATCCS suite. First, battle staff members must be trained to use the suite of ATCCS subsystems as an integrated system. They must learn to employ the optimal combination of ATCCS systems to acquire different information and to perform different tasks. Second, battle staff members must be trained to function as an efficient team in managing information that flows from or is accessible through the ATCCS systems.

Little information is available on how best to train battle staff members on the collective use of the ATCCS systems. Although an ATCCS has been fielded at the 4th Infantry Division (4ID), Fort Hood, Texas, there has been little time to develop and assess a method for training battle staff members on the collective use of the ATCCS. The research literature is replete with reports on team training, for example see the bibliography by Salas (Salas, 1997), but only one document has been located that describes research aimed specifically at information management by a team in a command and control setting (Freeman, Cohen, Serfaty, Thompson, & Bresnick, 1997). This document describes an excellent exploratory research project that was designed to identify (a) fundamental information management principles and procedures and (b) methods for training battle staff members to apply the information management principles and procedures. Freeman and his associates also discuss methodological problems that complicate the investigation of information management, including problems in assessing the effectiveness with which information is managed. Although the report by Freeman and his associates (Freeman et al., 1997) contains a great deal of useful information, the authors acknowledge that their work represents only a first step in a program of research that is needed to develop and validate methods to train battle staff members to manage information effectively.

Anticipating the delivery of ATCCS to Army aviation battalions, there is a pressing need to develop effective methods for training the battle staffs of Army aviation battalions on the collective use of the ATCCS systems. Battalion battle staff members must be trained on the optimal use of ATCCS systems for both planning and executing missions. Training on information management principles and methods must be considered an integral part of training on the collective use of the ATCCS systems.

A program of research is needed to develop and validate methods for training battle staff members on the collective use of ATCCS systems. An essential first step in this program of research is to develop methodology for research to (a) identify potential training methods and (b) assess the relative training and cost effectiveness of alternative training methods. It is essential that methodology be developed to assess the information management performance of battle staff members, individually and collectively.

Rationale

This section describes the rationale underlying the research approach and methods. This rationale is heavily influenced by the results of prior research on team performance, especially research on the performance of military command and control teams (Brannick, Salas, and Prince, 1997; Guzzo and Salas, 1995). The rationale is also influenced by research on naturalistic decision making, which has been conducted to gain a better understanding of how

decisions are made in a complex, dynamic environment such as a command and control center (Zsambok and Klein, 1997).

This study was not intended to be a classical experiment in which independent variables are varied systematically. A classical experiment was judged unsuitable for two reasons. The most practical reason is that the time and resources available were insufficient to conduct a productive experiment. More importantly, an experiment is not the most efficient approach for accomplishing the objectives of this study. So little is known about how best to use digital equipment in an Army aviation C^4I facility that it was not possible to identify, *a priori*, a set of independent variables that would be expected to determine observable behaviors in a controlled experiment.

Focus on Teamwork

A fundamental assumption underlying the research plan is that the observations should emphasize team behaviors (i.e., teamwork) over individual behaviors (i.e., taskwork). A considerable amount is known about how to train battle staff members in their functional-areas and about how to train digital equipment operators to perform their individual tasks. However, little is known about how best to train battle staff members and digital equipment operators to function effectively as an integrated team in a digital C^4I facility. Acquiring knowledge about the behaviors that lead to effective teamwork is an essential first step in developing effective TTPs and effective team training methods.

The focus on teamwork should not imply that the individual training of either the battle staff members or the equipment operators is adequate. To the contrary, survey data compiled recently (Thompson, Thompson, Pleban, and Valentine, 1991) show that most junior Cavalry and Infantry officers have had little or no functional-area training at the time they are assigned to a battalion battle staff position. Similarly, there is some anecdotal evidence that many of the individuals who are expected to operate the digital equipment in a digitized TOC are not adequately trained. Individual skills are important to the extent that deficiencies make it difficult or impossible to draw valid inferences about the behaviors that lead to effective team performance.

Types of Measures Required

Two types of performance measures were needed to accomplish the objectives of this study: outcome measures and process measures. As the name implies, outcome measures reflect the quality or desirability of the intermediate or final result of the mission exercises. Process measures reflect the type and quality of the activities, strategies, responses, and behaviors that are employed by the battle staff (Cannon-Bowers and Salas, 1997; Coovert, Cannon-Bowers, and Salas, 1990).

Outcome measures are important but are not fully adequate for present purposes. One reason is that outcome measures are not diagnostic; they provide no insight about why the outcome was favorable or not favorable. Another reason is that desirable outcomes may be the result of chance or simply good luck, rather than effective performance by the battle staff. In

such instances, drawing inferences only from the outcome measures might lead to the reinforcement of ineffective behavior.

Process measures are needed to understand the causal relationships between various performance elements (i.e., activities, strategies, responses, and behaviors) and outcomes. The processes of interest for this study are the tactics, techniques, and procedures (TTPs) employed by the battle staff. Only when key processes are well understood is it possible to specify the behaviors that lead to desired outcomes and the behaviors that do not. The processes that are considered important for this study are discussed below.

Key Processes

Although there are some processes that appear to be common to most types of teams, it is generally agreed that the processes underlying effective team performance differ to from one type of team to another. In identifying processes relevant to this study, we defined the following as the distinguishing characteristics of a battle staff viewed as a team:

- the team has a hierarchical structure;
- the individual responsibilities and duties of team members are reasonably well defined and stable,
- team members' tasks tend to be interdependent,
- there is a relatively small amount of overlap in the responsibilities and duties of team members,
- the large majority of both individual and team tasks involve the acquisition, processing, or distribution of information,
- the overriding team goal is to provide the information that the commander needs to assess the situation continuously and accurately, and
- the situation assessment must enable the commander to make rapid and tactically sound decisions about the need for intervention in the planned mission and the type of intervention that is required.

The processes described below are named and defined in a manner that is considered most meaningful for the study of teamwork among members of a battle staff. Virtually all of these processes have been identified and described by team performance researchers, albeit with varied terminology.

The processes that are causally related to the performance of a command and control team can be defined at different levels of generality. At the most general level, we have defined three key processes: *situation assessment*, *decision making*, and *workload management*; these processes can be thought of as "first tier" processes because they have a direct and immediate impact on mission outcome. At a lower level of specificity are the teamwork processes that are causally related to the first tier processes. The teamwork processes can be thought of as second tier processes because they influence mission outcome through one or more of the first-tier processes. The first-tier and second tier processes are discussed in the following paragraphs.

Establishment and sustainment of situation awareness. During the past 10 years, a state of cognitive awareness, referred to as situation awareness, has been found to have profound influence on the performance of a variety of complex tasks, including decision making in a command and control facility (Endsley, 1997). A recurrent problem in situation awareness research has been definition of the concept; several have been used. The following definition, though academic, provides broad applicability and pathways to observable behavior.

> "Situation awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future (Endsley, 1988).

This definition implies three levels of situation awareness. Level 1 is perception of critical elements in the environment; Level 2 is understanding the factors' meaning when interpreted in light of the goal; Level 3 is understanding what will happen in the near-term future. We believe that Endsley's definition is suitable for the present purposes.

When monitoring the progress of a tactical mission, the situation can change at any moment. Hence, the process of establishing and maintaining situation awareness—situation assessment—is a continuous process for which intensity (and by inference, resource requirements) may vary considerably from one mission segment to another. Although it is true that the commander's situation awareness has the most direct influence on decisions to intervene, the process of situation assessment is a team effort. That is, every member of the command and control team is responsible for seeking and transmitting information that contributes to the commander's situation awareness.

Tactical decision making. Tactical decision making has long been recognized as the process that has the most direct and immediate impact on command and control effectiveness. However, it is only in the last decade that meaningful research has been conducted to better understand how decisions are made in a dynamic, uncertain, and often fast paced environment such as a command and control facility. The research has shown that decisions in such situations are not made in accordance with the classical decision-making paradigm in which multiple options are identified and compared with one another. Rather, the research findings led to the identification of a Naturalistic Decision Making (NDM) process (Zsambok and Klein, 1997). A highly simplified concept of the NDM process is that the decision maker identifies the situation as familiar and recalls a course of action from memory) that is appropriate for such situations. The NDM process is aimed at identifying the first course of action that will work rather than identifying the optimal course of action among many options.

When evaluating the effectiveness of the battle staff, it certainly is important to assess the timeliness and tactical suitability of the decisions that are made. However, it is equally important to gain a better understanding of the cognitive processes through which decisions are made.

Workload management. Perhaps the greatest concern about the development and use of digitized C^4I systems is that the workload associated with processing the information will, at.

times, exceed the capacity of one or more members of the command and control team. This is a valid concern. The benefits of the enormous increase in information availability could be offset by the errors and inefficiencies that are the typical result of prolonged exposure to excessive workload. It is for this reason that workload management is expected to be influential with respect to effectiveness of battle staff performance. As is discussed below, reallocating functions among team members is one way to manage workload. Examples of other coping strategies include dropping a task altogether, attending to tasks in the order of their priority, accepting a delay in responding to task demands, and exerting more effort.

Teamwork Processes

The processes described below are named and defined in a manner that is considered most meaningful for the study of teamwork among members of a battle staff. Virtually all of these processes have been identified and described by team performance researchers, albeit with somewhat different names and definitions, and all have been found to have a major influence on the effectiveness of team performance under some circumstances.

Establish/maintain shared mission concept. Problems encountered during mission execution are sometimes explained by stating that "not all participants were playing from the same sheet of music." Researchers in team performance express the same idea by stating "participants' mental models of the mission differed in important respects." Both phrases accurately convey the notion that the participants' understanding of one or more characteristics of the mission differed enough to create problems. The term "shared mission concept" is used here to describe this important requirement for effective teamwork. More needs to be learned about (a) the types of problems that are caused by the lack of a shared mission concept and (b) the methods whereby a common mission concept can be established and maintained for all members of the battle staff.

Establish/maintain shared concept of team organization. Team performance can be seriously degraded by misunderstandings about the organization of a team. It is particularly important for team members to have a common understanding of (a) proper communication channels and (b) the duties and responsibilities of every team member. Establishing and maintaining a shared concept of team organization would be a fairly simple matter if the team organization remained constant over time. Battle staff organization may be expected to vary as a function of the commander's style of operation. However, it is likely that the team organization changes over time as a result of situational factors and team members' competencies. Information is needed about (a) the extent to which team organization changes over time, (b) the reasons for the changes, (c) the team members' perception of the changes, and (d) the best ways to establish and maintain a common concept of team organization.

Information screening. One of the concerns about digital C4I systems is the mass of information that is available to every equipment operator and battle staff member. A heavy flow of information imposes a requirement to filter the flow such that the information conveyed from one team member to another is relevant for the mission and relevant for the recipient of the information. There is no doubt that effective information screening is necessary to avoid (a) overloading the commander or some other team member with an excessive amount of

nonessential information or (b) denying the commander critically important information. However, we have found no useful guidance about who should be responsible for screening information (equipment operators, battle staff members, or both) or how to train personnel to screen information effectively.

Information pushing. An important characteristic of an effective team is that team members have a clear understanding of the information that is important to another team member and are sufficiently assertive to communicate the information in a timely and forceful manner. This may mean interrupting a superior in order to "push" the information to him or her. Many catastrophic events have occurred because a team member lacked the knowledge or assertiveness to "push" important information to another team member, so it is reasonable to assume that such problems occur in military command and control facilities such as a digitized TOC.

Information seeking. It is seldom, perhaps never, possible to access all the information that is needed to continuously assess the situation through passive monitoring alone. The digital information systems are designed such that important information is presented on different "pages" or different display modes. Hence, it is necessary for an equipment operator or a member of the battle staff to recognize information deficiencies and to acquired the information through database searches, page changes, display mode/format changes, or directing another person to acquire the needed information. The need to actively seek information may be stimulated by a recognition that (a) important information has aged and needs to be updated or (b) events have occurred that cannot be evaluated fully with the information available. In principle, the search for additional information can be initiated by an equipment operator or by any member of the battle staff. In practice, however, little is known about the cues that signal the need to seek additional information or who can and should be responsible for recognizing such cues.

Mutual monitoring. A team characteristic that appears to be important for every type of team is the capability and inclination of team members to monitor the performance of other team members and to alert other team members of errors of omission and commission. Mutual monitoring is particularly important for teams that are required to monitor a continuous stream of information. The equipment and personnel in the digitized TOC provide the capability for some amount of mutual monitoring. For example, members of the battle staff can view the monitors used by the equipment operators and the displays on the "video wall." More needs to be learned about the amount and type of mutual monitoring that is feasible and beneficial.

Coordination. As mentioned earlier, a distinguishing characteristic of battle staff is the task interdependency among the team members. That is, there are tasks that one team member cannot perform without information that must be provided by another team member. In such cases, job performance by a team member can be seriously degraded if information needed from another team member is delayed or not provided at all. To the extent that team members' tasks are interdependent, team performance will be heavily dependent on the degree of coordination in the exchange of information.

Backup behavior. For many types of teams, the workload of team members is highly variable and event dependent. The performance of the entire team can suffer when a team

member's workload becomes excessive. A characteristic of an effective team is the ability and inclination of one team member to help another team member whose workload has become excessive. Coming to the aid of a team member is referred to here and elsewhere as "backup behavior." Because backup behavior is recognized as an important contributor to team performance, there is a need to learn more about the potential for promoting more backup behavior in the digitized TOC.

Dynamic reallocation of functions. Backup behavior, discussed above, is one way to cope with excessive workload of a team member. Another way is for the team leader to direct a change in the allocation of functions (viz., responsibilities and duties) among two or more team members. Team performance under heavy workload conditions is closely related to the team members' capability to adapt quickly and effectively to a reallocation of functions. A battle staff leader's (commander or another member of the battle staff) options for dynamic reallocation of functions are largely determined by the degree of cross training by members of the battle staff.

Objectives

The broad objective of this study was to compile the data needed to address the requirements listed at the beginning of this introductory section. However, the specific objectives of this study were influenced by three other factors. First, the specific objectives were influenced by constraints imposed by (a) limited time, equipment, and personnel and (b) the requirement to use data collection methods that did not interfere with the training of the Aviation Officers Advanced Course (AVOAC) students. The constraints prevented the design and conduct of a classical experiment in which performance is measured as conditions (variables) are varied systematically. As a consequence, it was necessary to conduct an "observational study" in which behaviors and outcomes are observed and inferences are drawn about the behaviors (processes) that lead to desirable outcomes and those that lead to undesirable outcomes. It was also necessary to employ survey instruments and interviews to obtain information from the individuals who served as battle staff members during the study.

Second, the specific objectives were influenced by the lack of a proven methodology for quantifying and assessing information management methods and procedures. The observation methods that were employed were based on the assumption that an assessment of information management must focus on the type and volume of information that flows to and from each member of the battle staff, particularly the commander.

Third, the specific objectives were influenced by the need to identify exercise-design problems that must be taken into account when interpreting the findings. Unrealistic mission scenarios, inadequate mission planning resources (e.g., inadequate time, information, personnel), requirement to use nondoctrinal tactics are examples of potential exercise-design problems that were considered when designing this study.

Described below are the specific objectives established for the compilation of data about the events that occurred and the problems that were encountered during mission planning and during mission execution.

Objectives of Mission Planning Observations/Surveys

The objectives listed below influenced the compilation of information about mission planning activities and problems. To the extent possible, the study was designed to provide detailed information about the performance of each MDMP step. So, many of the objectives listed below apply to MDMP steps considered individually and collectively.

- Determine the manner in which the ATCCS systems are used during mission planning.
- Identify the problems that are encountered in using the ATCCS systems during mission planning.
- Determine the battle staff members who participate in each MDMP step/substep and assess the relative workload of the battle staff members.
- Determine the time spent on each MDMP step.
- Determine the adequacy of the time available for mission planning.
- Determine the adequacy of the information available for mission planning (type and accessibility of information).
- Determine the difficulty and realism of the mission being planned.
- Identify the need to establish/modify TTPs that govern mission planning activities.
- Identify the need for and function of an information manager (to manage information during mission planning).
- Determine the need for increased automation and identify the planning tasks/functions for which increased automation is needed.
- Identify knowledge and skill deficiencies that adversely influence mission planning quality and/or efficiency.
- Assess the observation methodology and the survey instruments.

Objectives of Mission Execution Observations/Surveys

The objectives listed below influenced the compilation of information about mission execution activities and problems. Many of the objectives are related to the measurement and assessment of information flow to and from the members of the battle staff and other battlefield elements.

- Determine the manner in which the ATCCS systems are used during mission execution to acquire and disseminate information.
- Identify the problems that are encountered in using the ATCCS systems during mission execution.
- Quantify the type and volume of information that flows to and from members of the battle staff, with special emphasis on the information flow to and from the commander.

- Determine the frequency with which the commander acquires information through the supply-push method or the demand-pull method.[1]
- Identify the incidence, consequences, and causes of excessive information processing workload.
- Assess the utility of a wall-mounted video display[2] for disseminating information to the commander or to other members of the battle staff.
- Identify the need to establish/modify TTPs that govern (a) monitoring the execution of the decision support template, (b) the management of information, and (c) other mission execution activities.
- Identify the need for and functions of an information manager (to manage information during mission execution).
- Identify knowledge and skill deficiencies that adversely influence the quality of the mission outcome or the efficiency of the mission execution activities.
- Assess the observational methodology and the survey instruments.

Method

Facilities and Equipment

This study was conducted in two major facilities: the Army Aviation Test Bed[3] (AVTB) and the Aviation Warfighting Simulation Center (AWSC). The AVTB and AWSC are interconnected with a fiber optic cable network; both facilities are located at the USAAVNC, Fort Rucker, Alabama. The AVTB and the AWSC are simulation facilities that can be reconfigured to support a wide range of Army aviation research. The configurations employed for this study are described below.

Brigade and Battalion TOCs

Both the brigade TOC (located in the AVTB) and battalion TOC (located in the AWSC) were configured as simulated digitized TOCs using a partial installation of the ATCCS suite. The brigade TOC served as a control center during this study. All the observational data that were compiled during this study result from the observations of events and activities that occurred in the battalion TOC. The brigade and battalion TOCs each had three cells: a current operations cell, a plans cell, and an ALOC. Each of the three cells is described below.

Current operations cells. The current operations cells were designed to accommodate the battle staff members who participated in the execution of missions and support their functions. During the period between missions, mission planning discussions sometimes took place in the current operations cells, but virtually all mission planning tasks were performed in

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[1] The supply-push and the demand-pull methods of acquiring information are defined and discussed in the Findings section of the report under the heading "Information Flow/Management." For present purposes, demand-pull means that the information was conveyed as a result of an overt request for the information. Supply-push means that information was conveyed to an individual without it being overtly requested by that individual.
[2] As discussed in a later section of the report, the wall-mounted video display is capable of portraying information from any of the ATCCS systems.
[3] The AVTB was formerly known as AIRNET.

the plans cells. Both current operations cells were equipped with the digital systems that are listed below. Note that the last two are not workstations but passive information displays.

- ASAS
- MCS
- AFATDS
- AMDW/S
- FAADEO
- JSTARS - MTI. JSTARS is a wide area airborne surveillance system that provides battle management and targeting information to the commander and staff. It detects moving and fixed targets with accuracy that afford precision strike engagements at extended ranges. The JSTARS Moving Target Indicator (MTI), which presents a symbolic depiction of the moving objects present in the ground area covered by the display.
- Tactical Unmanned Aerial Vehicle (TUAV) Display—The TUAV display presents raw video imagery of terrain and ground-based targets as seen from an airborne TUAV as modeled through a simulation-based interactive eyepoint.

In addition to the suite of digital systems described above, the operations cells were equipped with a radio system emulator and a "video wall." The 16-channel radio system emulator, produced by Advanced Simulation Technology, Inc. (ASTi), was capable of simulating the line-of-sight and range limitations of operational FM radios. Because headphones were not available, voice messages were heard on small speakers located at most but not all workstations in the current operations cells.

The video wall contained a large screen display (35 inch diagonal) placed 44 inches above the floor. This was surrounded on three sides (top, left, and right) by eight small screen displays (17 inch diagonal). The video wall displays were connected to a switching system that enabled operators to display the AFATDS output, the JSTARS output, the TUAV video, the ASAS output, or the AMDW/S output on any one of six small screen displays[4] or on the large screen display.

Plans cells. The plans cells in the brigade battalion TOCs were designed to serve as future operations planning areas for use by the members of the battle staff who participated in mission planning. In addition to work tables, map boards, and other mission planning materials, the plans cells were equipped with an ASAS Remote Work Station (RWS) and an MCS station. Both the ASAS-RWS and the MCS station were capable of transmitting data to and receiving data from the current operations cells via tactical Internet.

ALOC cells. The ALOC cells were designed to accommodate the personnel responsible for the planning and coordination of combat service support (CSS) and facilitate their functions. Both ALOC cells were equipped with an MCS and CSSCS workstation. Voice communication between the ALOC cells and the current operations cells was accomplished with the radio system emulator.

[4] Two of the eight small screen displays were spares.

Aircraft Simulators

This study employed six Simulation Network (SIMNET) Fully Reconfigurable Experimental Devices (FREDs)[5] located in the AVTB. Three FREDs were configured as AH-64A aircraft, two were configured as OH-58D aircraft, and one was configured as a UH-60 aircraft. The six FREDs were networked together and networked with the simulation components described in the next subsection. All FREDs had virtual (out-the-window) displays that were generated from the same digital topography (Grafenfels database). Each FRED was occupied by a company commander and a pilot or by two pilots. Each was connected to the radio emulator network.

Company TOC

An area in the AVTB was designated as a company-level TOC. The company TOC was used by the company commanders and pilots to plan their missions. The company TOC was not occupied during the time that missions were being conducted. The company TOC was equipped with maps and other planning materials, but was not equipped with any digital system.

Simulation/Interface Components and Systems Modeled

The ATCCS digital subsystems and displays and the FREDs received tactical message inputs from constructive and virtual interfaces through a distributed interactive simulation (DIS) local area network (LAN) and wide area network (WAN). The tactical messages, in turn, were determined by a synthetic battlespace environment that was generated by the simulation components and interface components listed below.

- Computer Generated Forces: Modular Semi-Automated Forces (CGF ModSAF)
- Tactical Simulation Interface Unit (TSIU)
- Extended Air Defense Simulation (EADSIM)
- TUAV Simulation (MetaVR)
- Protocol Interface Unit (PIU)
- Target Acquisition Fire Support Model (TAFSM)
- Sensor/C^4I Simulation

The simulation and interface components used for this study had the capability to simulate (model) both friendly (blue) and enemy (red) maneuver forces and aircraft (fixed-wing and rotary-wing). In addition, the simulation components listed above had the capability to generate an airborne visual sensor and the following weapons systems:

- Army Tactical Missile System/Multiple Launched Rocket System (ATACMS/MLRS),
- Phased Array Tracking Intercept of the Target (PATRIOT) Missiles,
- Cruise Missiles, and
- Threat Transporter-Erector-Launcher (TEL) Missiles.

[5] A FRED is a fixed-base aircraft simulator that can be reconfigured to simulate different types of rotary-wing aircraft or semi-permanently to represent a fixed-wing aircraft.

After Action Review (AAR) Area

A briefing room, located in the AWSC, was used to conduct AARs. This room had a large enough seating area to accommodate all the personnel who were involved in the study. It was equipped with three front projection screens and a suite of projectors for displaying slides, transparencies, and video imagery. The video projector was used to project imagery from a video recorder and imagery from a computer (viz., Powerpoint slides). In addition, the display facilities of the AAR room could be fed imagery from various sources within the battalion TOC ATCCS suite.

Personnel

Three categories of personnel provided support for this study. One category was the company commanders and pilots who performed the company-level mission planning and who occupied the FREDs during the mission executions. The second category included the personnel who served as members of the battalion battle staff. The third group included the personnel who served as members of the research support staff. Each of the three groups of personnel is described below.

Company Commanders and Pilots

Three individuals served as commanders of attack helicopter companies during this study. A company commander occupied each of the three FREDs that were configured as an AH-64A aircraft. The three individuals who served as company commanders, all qualified Army aviators, were in the process of completing AVOAC, class 98-1, at the time the study was conducted. Nine individuals who served as FRED pilots (3 AH-64As, 4 OH-58Ds, and 2 UH-60s) were casual officers assigned to the First Battalion of the 145th Aviation Regiment (1/145), First Aviation Brigade; all were qualified Army aviators.

Battalion Battle Staff

A group of 12 Army aviators served as battalion battle staff members during all or a part of this study. Eleven of the aviators were in the process of completing the AVOAC, class 98-1. One aviator was a company commander in the 1/145 at the time they participated in this study. At the outset of the study, an individual was assigned to each of the following battle staff positions:

- Commanding Officer(CO),
- Executive Officer (XO),
- Battle Captain (BC),
- Assistant Battle Captain (ABC),
- Personnel Officer (S1),
- Intelligence Officer (S2),
- Assistant S2 (AS2),
- Operations and Training Officer (S3),
- Assistant S3 (AS3),

- Supply Officer (S4),
- Fire Support Officer (FSO), and
- Air Defense Officer (ADO).

With the following four exceptions, individuals retained the same battle staff position throughout the study:

- the ABC and BC exchanged positions on one day;
- the S2 and AS2 exchanged positions on one day;
- the ABC served as an AS3 on two days (the ABC position remained unfilled on those days); and
- because of personal problems, the individual who was assigned to the ADO position was present only for a part of the first day of the study.

The reasons for the changes in positions are not completely known. The move of the ABC to the AS3 position was probably motivated by the need to increase the manpower available for mission planning. The exchange of the S2 and AS2 positions and the exchange of the BC and ABC positions were probably motivated by the desire to provide training in more than one position.

Before proceeding, it should be noted that the BC and ABC (when the ABC position was filled) occupied the battalion current operations cell during all mission execution exercises and most of the time between mission execution exercises. For this reason, neither the BC nor the ABC participated actively in mission planning. It should also be noted that the officers who were assigned to the BC and ABC positions during this study were not given detailed instructions on the duties of a BC or an ABC. The failure to instruct the BC and ABC on their specific duties and responsibilities probably is due to the fact that (a) the position of BC is not a Table of Organization and Equipment (TO&E) position and (b) the position of BC is not addressed in any doctrinal publication (de Oliveira, 1998).

Research Support Staff

Brigade battle staff. The brigade TOC was used solely to promote exercise realism and to control the exercises. Hence, all personnel who served as members of the brigade battle staff were members of the research support staff. During the periods when missions were conducted, a Commander, an S2, an S3, an S4, and an FSO usually occupied the brigade TOC. The individuals who served as members of the brigade battle staff were thoroughly knowledgeable about the research objectives and procedures and were experienced in performing the duties of their assigned staff positions.

Equipment operators. Members of the research support staff operated all of the digital systems located in the brigade TOC. In addition, members of the research support staff assisted the battalion battle staff in operating the ASAS and the MCS during mission planning and mission execution. Two research staff members occupied the battalion plans cell during all scheduled mission planning sessions. One staff member provided assistance in operating the ASAS, and the second provided assistance in operating the MCS. Two other members of the

research support staff occupied the battalion TOC current operations cell during all mission execution exercises and most of the periods between mission execution exercises; one staff member provided assistance in operating the ASAS, and the other provided assistance in operating the MCS. Two staff members provided parallel support in the brigade TOC.

Members of the research support staff were responsible for programming and operating all of the simulation and interface components.

Observers. Ten members of the research staff served as observers. They were responsible for observing and recording events and activities that occurred during all mission planning sessions and during all mission execution exercises. One observer occupied the brigade TOC, and nine observers occupied the battalion TOC. The brigade TOC observer occupied the current operations cell at all times when members of the research staff were preparing for or conducting a mission. The locations occupied by the battalion TOC observers are described below.

Five of the battalion TOC observers occupied the current operations cell on the four days during which missions were conducted. Because some planning activities were performed in the current operations cell, observers occupied the current operations cell throughout the day. The battalion TOC current operations cell was not occupied on Day 3, because no missions were conducted on that day; all members of the battalion battle staff were engaged in mission planning on Day 3.

Three battalion TOC observers occupied the plans cell or the adjacent briefing room during all scheduled mission planning sessions (including mission planning briefings). In a few instances, battle staff members engaged in mission planning activities after the regularly scheduled times. No observers were present at the after-hours mission planning sessions. One observer occupied the battalion ALOC during all times when battle staff members were present and engaged in either mission planning or mission execution activities.

Six observers were Army personnel who were serving active duty assignments at the USAAVNC; two were Captains and four were NCOs. The two Captains were qualified, current Army aviators. The remaining four observers were civilians; three were government employees, and one was a government contractor. Three of the civilian observers were actively involved in the development of the research methodology, including the development of (a) the observation procedures and forms and (b) the survey instruments.

Procedures

Pre-Exercise Training

Prior to the start of the exercises, it was necessary to train the members of the battalion battle staff, company commanders and pilots who occupied the FREDs, and the observers. The training received by each group is described below.

Battle staff training. All members of the battalion battle staff received four hours of training on the layout of the battalion TOC and the equipment present in each cell. The battle staff members were given a comprehensive briefing on (a) the functions and capabilities of each ATCCS subsystem, (b) the function and interpretation of the information displays, and (c) the function and operation of the radio emulator. Subsequently, the battle staff members participated in two days of rehearsals in the digitized TOC. The rehearsals provided all members of the battle staff an opportunity to practice performing the duties of their assigned positions and to practice operating the digital systems. Members of the research staff were present during the rehearsals to help battle staff members learn to operate the digital systems. Battle staff member training and rehearsals were conducted during the period February 24-27, 1998.

Company commander and pilot training. The company commanders and pilots received eight hours of training on the FREDs. The training included a briefing on the FRED displays and controls and the characteristics of the synthetic battlespace environment. The company commanders and pilots spent the remaining time in the FREDs acquiring skills in controlling the simulated aircraft, firing weapons, and communicating. Training of the company commanders and pilots was conducted on February 21, 1998, and on February 23, 1998.

Observer training. During a 90-minute ATCCS familiarization briefing on February 24, 1998, observers were briefed on the layout of the battalion TOC and the function of each ATCCS digital subsystem and information display. The following day (February 25, 1998), all observers attended a 2-hr. training session on data collection procedures. Observers were first briefed on the problems and concerns that led to the study and the specific objectives of the study. Observers were briefed on (a) the data collection procedures and instruments to be employed, (b) the schedule of data collection activities, and (c) the specific responsibilities of each observer. Observers then were provided copies of the observation data forms (mission planning form and mission execution form) and given detailed instruction on (a) the events and activities that must be observed and (b) the manner in which observation data must be recorded (encoded) on the observation data forms.

At the end of the first, second and final days of observations, all observers met for about 1 hour to discuss problems that were encountered during the day and, when necessary, to refine the observation procedures and forms.

Missions Planning and Execution

Members of the battalion battle staff were engaged in mission planning sessions and mission execution during the 5-day period starting at 0730 on March 2 and ending at 1600 on March 6, 1998. The mission planning and mission execution activities were a part of a one-week training exercise in which all the students participated at the end of the AVOAC. Because the primary purpose of the exercises was to train the AVOAC students, no data collection methods or procedures could be used that might degrade the training effectiveness of the exercises. Moreover, it was not possible to change the mission scenarios in any way that would decrease the training effectiveness of the exercises.

Described below is the scenario that provided the structure for mission planning and mission execution events and activities. The scenario description is followed by a description of the key events and activities that occurred each day.

Overview of scenario.[6] The study scenario was based on the Warfighter Training Support Package (TSP) for the Digitized Aviation Brigade and Division Cavalry Squadron. The study group represented the 1-4 Attack Helicopter Battalion (AHB) of the 4th Aviation Brigade, 4ID, Mechanized. In addition to the three companies of AH-64As (24 aircraft), a platoon of UH-60s (4 aircraft) and a team of OH-58Ds (2 aircraft) were provided by OPCON (operational control) to the AHB. The brigade level OPORD and fragmentary orders (FRAGOs) issued to the AHB were developed by the Warfighting Futures Division (WFD) of DOTDS, based on the TSP division level order and FRAGOs 1-3. A "911" mission also was issued on the last day of the study based on TSP FRAGO 4. The term "911" is an informal descriptor for any emergency or unplanned set of events that necessitate a hasty operation. Additional complementary missions (e.g., combat search and rescue [CSAR], reconnaissance, general support [GS]) were executed on order from the brigade TOC (control cell).

For this study, each of the FREDs that was configured as an AH-64A represented a company of eight AH-64A Apache helicopters. One FRED configured as a UH-60 Blackhawk helicopter represented a platoon of four UH-60s. Two FREDs configured as OH-58D Kiowa Warrior helicopters represented a team of two OH-58Ds.

Day 1 events/activities. The base OPORD was issued at the start of Day 1.[7] Members of the battalion battle staff commenced planning immediately after they received the OPORD and continued planning throughout the day. Other events that occurred during Day 1 are listed below.

- Brigade sent an urgent resupply request to the battalion.
- The resupply mission was assigned to the UH-60 platoon.
- During the resupply mission, the UH-60 crew observed and reported enemy reconnaissance vehicles.
- Brigade ordered the OH-58D team to gain contact with enemy vehicles and to develop the situation.
- The TUAV supported the missions and supported a search for downed aircraft.
- Company commanders were briefed on the mission scheduled for Day 2.

Day 2 events/activities. The main mission during Day 2 was to conduct a deep attack against an enemy surface-to-surface missile site. The activities commenced with the launch of the TUAV. Shortly thereafter, the brigade commander issued a FRAGO for an AH-64 company to conduct a screen mission. Subsequently, the brigade commander issued a FRAGO to conduct a deep attack against the missile site.

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[6] The description of the study scenario was paraphrased from the description in the Exercise Support Plan prepared by Coleman Research Corporation (Schmidt and Shehan, 1998).
[7] The date corresponding with Day 1 is March 2, 1998.

Day 3 events/activities. Day 3 was devoted solely to mission planning. No missions were executed in the battalion TOC on Day 3.

Day 4 events/activities. Day 4 activities commenced with a rehearsal of the deep attack mission scheduled for the afternoon of Day 4. The mission rehearsal was completed, and the deep attack mission was conducted as scheduled. The rehearsal and the mission involved the use of the TUAV for target and route reconnaissance and the use of the OH-58Ds for reconnaissance and attack support.

Day 5 events/activities. Day 5 activities commenced with a rehearsal of the hasty attack mission scheduled for the afternoon of Day 5. The mission rehearsal was completed successfully, and the deep attack mission was conducted as scheduled. The rehearsal and the mission involved the use of the TUAV for target and route reconnaissance and the use of the OH-58Ds for reconnaissance and attack support.

Demographic Questionnaire and Consent Form

All members of the battalion battle staff reviewed and signed a Consent Agreement. The Consent Agreement described the purpose of the study and the type of information that the battle staff members would be asked to disclose. The Consent Agreement explained that the information would remain confidential and that battle staff members had the right to refuse to provide information without risk of negative consequences.

At the end of Day 1, all members of the battalion battle staff completed a Demographic Questionnaire. The Demographic Questionnaire was designed to acquire information about staff members' age, grade, Specialty Skill Indicator (SSI), Primary Occupational Specialty (PMOS), years of military experience, current duty assignment, education courses and technical schools attended, experience as a battle staff member, and knowledge of the functional capabilities and operation of the digital systems present in the battalion ATCCS.

Appendix A contains a copy of the Consent Agreement and a copy of the Demographic Questionnaire.

Mission Planning Questionnaire

A Mission Planning Questionnaire was completed by all members of the battalion battle staff on three occasions. On the first occasion, battle staff members answered questions about the planning that was accomplished on Day 1 (March 2) and on part of Day 2 (March 3). On the second occasion, battle staff members answered questions about the planning that was accomplished on Day 3 (March 4). On the third occasion, battle staff members answered questions about the planning that was conducted on Day 4 (March 5). Appendix B contains a copy of the Mission Planning Questionnaire and the list of MDMP steps and substeps that was attached to the questionnaire; a brief description of the questionnaire items is presented below.

The first group of items on the Mission Planning Questionnaire asked battle staff members to provide information about the amount of time they spent planning the mission and

the difficulty of planning the mission (relative to the difficulty of planning a live operational mission). The following item asked battle staff members to rate mission realism relative to the realism of a live operational mission. One item asked battle staff members to indicate the need for and the functions of an information manager who would manage information during mission planning. A series of items asked battle staff members to provide a separate response for each of six MDMP steps. Responses for each MDMP step were required for each of the following queries:

- highest workload experienced,
- adequacy of time and information (type and accessibility),
- errors or oversights made,
- adequacy of knowledge of the digital equipment operation and functions,
- adequacy of TTPs,
- need for additional automation, and
- adequacy of prior training.

Every item had an open-end part that invited the battle staff member to provide a written explanation of the answers or opinions expressed in the quick-response (i.e., checklist) part of the item.

Mission Planning Observations

Three observers were responsible for observing selected events and activities that occurred during the mission planning sessions. The three observers worked as a team in completing the Mission Planning Observation Form shown in Appendix C. The mission planning observers were responsible for recording selected information about each of the following MDMP steps.

- Step 1: Receive the Mission
- Step 2: Analyze the Mission
- Step 3: Develop the Course of Action (COA)
- Step 4: Analyze the COA
- Step 5: Compare the COA
- Step 6: Approve the COA

Observers recorded the time that work on each MDMP step commenced and the time that work on the step was completed. As each MDMP step was being completed, observers recorded the MDMP substeps that were accomplished, the battle staff members who participated in each substep, and the members of the support staff who participated in the step. When an MDMP step had been completed, observers were instructed to identify problems encountered in performing the MDMP step and the battle staff member(s) who encountered the problem. Space was provided on the Mission Planning Observation Form for observers to describe instances of each of the following problems:

- important information not available,
- important information not easily accessible,

- excessive workload,
- lack of knowledge about the functional capabilities of digital equipment,
- lack of skill in operating digital equipment,
- inadequate TTPs,
- lack of training/experience on the MDMP, and
- other problems.

After the mission planning had been completed, observers were required to provide written descriptions of mission planning errors or oversights that they observed. Observers also were asked to record their judgments about (a) the need for increased automation, (b) the need for an information manager, and (c) the need for additional training of battle staff members.

Mission Execution Observations

Six observers occupied the battalion TOC for the entirety of Day 1, Day 2, Day 4, and Day 5. One observer was assigned to each of five observation stations within the battalion TOC and was instructed to observe the activities of the members of the battle staff who were present at that station. The sixth observer, a backup observer, occupied an observation station during the time that the regular observer took a break. The five observation stations are listed below along with the personnel who were present at the observation station all or some of the time. Station 5 was located in the ALOC; all other stations were located in the current operations cell.

- Station 1: S2, AS2 (ASAS operator), support staff member (ASAS operator), and BC
- Station 2: S3, AS3 (MCS operator), support staff member (MCS operator), and ABC
- Station 3: CO and XO
- Station 4: FSO and support staff member (AFATDS operator)
- Station 5: S1, S4, support staff member (CSSCS operator)

Appendix D shows a copy of the Mission Execution Observation Form[8] that observers used to record information about events and activities that occurred during the execution of a mission. Observers were instructed to record information on (a) voice communication events and (b) other problems and events. For each voice communication at an observer's station, the observer recorded the time the voice communication was initiated, the person who initiated the communication, and the person to whom the communication was directed. Observers also recorded the content of the communication (actual or paraphrased) and classified the message by checking one of five alternatives, which are listed and defined below.

- Request for Information: This alternative was checked when the message was a request for information.
- Response to Request: This alternative was checked when the message was a response to a prior request for information.

[8] The Mission Execution Observation Form shown in Appendix D is a smaller version of the form that was used by observers. Although the Form in Appendix D shows all the information that appeared on the actual form, the space available for notes was reduced in size to make the form fit on a standard 8½-in x 11-in sheet.

- Information Push: This alternative was checked when an individual conveyed information to another individual without being requested to do so.
- Situation Update: This alternative was checked when the communication was a situation update that was provided by one individual for the benefit of other individuals (two or more).
- Coordination: This alternative was checked when the purpose of the communication event was an extended dialog intended to coordinate the actions of the two or more persons involved in the conversation.

The observers were instructed to record (a) problems that may have influenced the outcome of the mission, (b) key decision points that occurred during the mission, and (c) the time at which the problem or decision point occurred. The Mission Execution Observation Form was designed such that observers could place a checkmark in a box that corresponded with events of particular interest. The events that could be checked by observers are listed and defined below.

- Excessive Workload: This alternative was checked when the observer judged that the workload of a staff member was excessive.
- Inadequate Situation Awareness: This alternative was checked when the observer judged that a staff member lacked an adequate level of situation awareness.
- Decision Point: This alternative was checked when the situation required a staff member to make a decision, whether or not a decision was made.
- Decision Error: This alternative was checked when a decision by a staff member may have had an adverse effect on the mission outcome.
- Skill Deficiency: This alternative was checked when there was evidence that a staff member lacked the knowledge or skill needed to perform his or her job.
- Other: This alternative was checked when an event other than those listed above may have had an adverse effect on the mission outcome.

When any of the above options were checked, observers recorded the position of the staff member who experienced the event (problem or decision point) and wrote a brief description of the event.

After Action Reviews (AARs)

An AAR was conducted immediately after the completion of each mission execution exercise. All members of the battalion battle staff, the company commanders, the FRED pilots, and most members of the research support staff attended the AARs. Each AAR commenced with a detailed review and assessment of the mission just completed. Although a member of either the research support staff or instructional staff directed the review and assessment, members of the battalion battle staff were often invited to comment on key events that occurred and key problems that were encountered during the mission.

Following the review and assessment of the mission, all attendees were invited to identify and discuss problems encountered and "lessons learned" from either the planning or the execution of the mission.

Training Effectiveness Questionnaire

After completing the last mission execution exercise (Day 5), all members of the battalion battle staff completed a Training Effectiveness Questionnaire (see Appendix E). The Training Effectiveness Questionnaire required battle staff members to rate their level of agreement with 30 different statements related to the training effectiveness of the ATCCS suite of digital systems and virtual systems.

Post-Exercise Interviews

During the week following the completion of the exercises, two members of the research staff conducted detailed interviews with the XO, the S1, the S2, the S3, and the S4. Three interview sessions were conducted: one with the XO, one with the S1 and S4, and one with the S2 and S3.

The interview with the XO focused on two topics. The first topic was the adequacy of the ATCCS digital systems for establishing and sustaining the situation awareness of the commander. The second topic was the need for an information manager and the duties of an information manager.

The interview with the S2 and S3 focused on the utility of the digital systems for mission planning. The S2 and S3 were questioned in detail about the MDMP tasks that were facilitated by the digital systems and those that were not facilitated. The S2 and S3 were invited to identify and discuss design improvements that may increase the utility of the digital systems for mission planning.

The interview with the S1 and S4 focused on the utility of the CSSCS for mission planning and mission execution. The S1 and S4 were asked to identify the types and causes of the problems they encountered during mission planning and execution. They also were asked to identify and discuss design improvements that may increase the utility of the CSSCS for mission planning and/or mission execution.

Findings

This subsection has four major parts. The first part describes the demographic characteristics of the battle staff members who served as members of the battalion battle staff. The second part describes the data compiled from questionnaires about mission planning and from direct observations of each mission planning session. The third part describes the data compiled from direct observations of the execution of each mission and from survey forms that were completed by battle staff members after the completion of each mission. The fourth part is a synopsis of the problems described by battle staff members. The synopsis includes problems described by battle staff members on their survey forms and problems discussed during the AARs or the post-exercise interviews.

Data Presentation and Analysis

As was stated earlier, this was an observational study rather than a classical experiment. The intent was to observe the manner in which the battle staff members performed their jobs (individually and collectively) and to draw inferences about the manner in which the behaviors influenced the outcomes. Accordingly, inferential statistical procedures are inappropriate. Descriptive statistics were employed in documenting the findings. The descriptive statistics presented in the following pages include percentage values, frequencies, means, medians, and modes. However, some readers may desire an estimate of the likelihood that a difference among percentage values (or differences among frequencies) could have occurred by chance. To satisfy this need, Chi Square (symbolized χ^2) values have been calculated and presented in a number of instances (Guilford and Fructer, 1978). These provide a basis for evaluating the likelihood that a difference between frequencies represents a chance fluctuation. However, it is important to emphasize that the χ^2 values cannot be used to draw inferences about whether differences are representative of the differences that would occur with other battle staffs or other missions. In other words, the reader is cautioned not to generalize the results indicated by the χ^2 values presented to any other exercise or other sample of behavior. Because of the type and amount of data compiled during this study, there are virtually thousands of differences in frequencies (or percentage values) that could be assessed. Not all of the possible comparisons have relevance to the objectives outlined for the study.

In some instances, only two frequencies were compared. For these, the null hypothesis being tested is that the two frequencies are the same (e.g., the number of battle staff members who responded "yes" to a questionnaire item is the same as the number who responded "no"). In other instances, a contingency χ^2 value was computed to test the null hypothesis that more than two frequencies are the same (e.g., the number of battle staff members who responded "yes" was the same for each of the seven MDMP steps). Some comparisons involve samples that are not independent. For example, participants were given the same set of surveys after each mission. Their responses would be considered repeated measures and therefore not independent. In these cases the sample values have been converted to differences between or among samples matched by respondent. The null hypothesis tested is that the difference scores equal zero. Unless stated otherwise, χ^2 statistics are not be considered significant indicators of response differences unless the probability that the χ^2 value occurred by chance equals or is less than 5% ($p \leq .05$).

Battle Staff Member Characteristics

Some relevant characteristics of the individuals who served as members of the battalion battle staff are summarized in Table 1. The information in Table 1 was extracted from the Demographic Questionnaire (see Appendix A) that battle staff members completed on the first day of the study. The first row of Table 1 shows the battle staff position to which each individual was assigned at the outset of the study. As stated earlier, most battle staff members remained in the position to which they were assigned initially. On one day, the S2 exchanged position with the AS2 and the BC exchanged positions with the ABC. On two days, the ABC assumed the position of BC, and the BC served as another AS3; the position of ABC was not filled on these days. Because the position of ADO was filled for only part of one day, no information is presented for the individual who was assigned to the ADO position.

All battle staff members were rated rotary wing aviators and commissioned officers. The CO and XO held the rank of Major (MAJ) and had 17 and 15 total years of military service, respectively. All of the remaining battle staff members held the rank of Captain (CPT) and had between 5 and 11 total years of military service. All battle staff members except the CO were in the process of completing the AVOAC at the time the ATCCS study was conducted; the XO was the class leader of AVOAC class 98-1.

The CO, XO, and S3 had served as a company commander, and the CO and XO had served as a battalion assistant S3. The XO also had served as a battalion S1. Five of the remaining 8 battle staff members (S2, AS3, S4, FSO, and ABC) had at least 5-months of experience in a battalion battle staff position. However, none of the 11 battle staff members had prior experience in the battle staff position to which they were assigned in the ATCCS study. Three battle staff members (S1, AS2, and BC) had no prior experience serving as a member of a battalion battle staff.

Table 1

Characteristics of the individuals who served as a member of the battalion battle staff.

QUESTIONNAIRE ITEM	BATTLE STAFF MEMBER RESPONSES										
Assigned Battle Staff Position	CO	XO	S1	S2	AS2	S3	AS3	S4	FSO	BC	ABC
Current Rank	MAJ	MAJ	CPT	CPT	CPT	CPT	CPT	CPT	CPT	CPT	CPT
Age (years)	35	33	29	29	28	28	31	29	26	28	27
Active Component Service (years)	15	10	5	6	6	6	7	11	5	6	5
Reserve Component Service (years)	2	5	4	0	0	0	0	0	0	0	1
Total Service (years)	17	15	9	6	6	6	7	11	5	6	6
Experience as Battle Staff Member (months)	48	24	0	13	0	15	5	18	9	0	20
Knowledge of JSTARS Capabilities/Operation	3/1	2/1	2/1	3/1	3/2	3/1	1/1	1/1	1/1	2/2	2/1
Knowledge of ASAS Capabilities/Operation	2/1	1/1	2/1	2/1	2/2	3/3	1/1	1/1	1/1	2/2	2/1
Knowledge of AFATDS Capabilities/Operation	2/1	1/1	2/1	1/1	2/2	3/2	1/1	1/1	1/1	2/2	2/2
Knowledge of MCS Capabilities/Operation	2/1	1/1	2/1	1/1	2/2	3/3	1/1	1/1	1/1	2/2	3/3
Knowledge of FAADEO Capabilities/Operation	2/1	1/1	2/1	1/1	2/2	3/1	1/1	1/1	1/1	2/2	1/1

Note. The pairs of numbers in the last five rows are rating values used by battle staff members to rate their knowledge of the functional capabilities of the corresponding digital system (first number) and their skill in operating the system (second number). The rating values varied from 1 (no knowledge/skill) through 5 (high knowledge/skill).

Battle staff members were asked to rate (a) their knowledge of the functional capabilities of each of five digital systems and (b) their skill in operating each system. The rating scale used by battle staff members varied from *none* (rating of 1) through *moderate* (rating of 3) to *high* (rating of 5). Battle staff members' ratings are shown in the five lines at the bottom of Table 1. Both ratings are shown in the same cell; the first number (before the slash) is the rating for knowledge of functional capabilities, and the second number (after the slash) is the rating for skill in operating the system.

The ratings show that few battle staff members had even a moderate (rating of 3) level of knowledge about the functional capabilities of any digital system; even fewer battle staff members had even a moderate level of skill in operating any system. Of the 55 ratings, 43 (78%) are 1 (none) or 2 (slight); the remaining 12 ratings (22%) are 3 (moderate). These ratings are consistent with numerous comments by battle staff members that, at the outset of the study, they were severely handicapped by their knowledge and skill deficiencies in using the digital systems for mission planning and for mission execution.

Mission Planning

Data about mission planning came from (a) a mission planning questionnaire completed by each battle staff member and (b) notes and data forms completed by the members of the research support staff who were responsible for observing all mission planning activities. The data from these two sources are discussed in turn.

Mission Planning Questionnaire Responses

Each battle staff member completed a mission planning questionnaire (see Appendix B) on three occasions. On the first occasion, battle staff members answered questions about the planning that was accomplished on Day 1 (March 2) and a part of Day 2 (March 3). On the second occasion, battle staff members answered questions about the planning that was accomplished on Day 3 (March 4). On the third occasion, battle staff members answered questions about the planning that was conducted on Day 4 (March 5). Throughout the discussion of mission planning, it is implied that a separate mission was planned during each of the planning sessions. For example, the tables and charts show planning data for Mission 1, Mission 2, and Mission 3. The planning conducted during the sessions dealt with different FRAGOs, but the OPORD remained the same. Although all of the planning was in response to the same OPORD, the first and the third mission planning sessions required battle staff members to perform all of the MDMP steps, and the second session required battle staff members to perform most of the MDMP steps.

Because few battle staff members changed battle staff positions from one planning session to the next, all responses are presented by battle staff position rather than by individual.

Time spent planning. The BC and ABC were not required to play an active role in mission planning. The BC spent no time on mission planning, and the ABC spent only 3 hours on planning Mission 2 and 1 hour helping to plan Mission 3. The hours the remaining battle staff members spent planning each mission are shown in Table 2. For Mission 2 and 3, two

AS3s participated in mission planning. Table 2 shows the planning time each of the AS3s spent planning Mission 2 and Mission 3 (e.g., the entry 14/10 means one AS3 spent 14 hours, and the second AS3 spent 10 hours planning Mission 3).

The S1 spent only 2.0 hours planning each of the three missions. All other battle staff members spent no less than 6.0 hours and as many as 16 hours planning a mission. When averaged across battle staff members, the mean time per mission ranges from 9.6 hours (Mission 1) to 10.8 hours (Mission 3). When averaged across missions, the mean time per mission is similar for all battle staff members except the S1. The mean planning time for the S1 is only 2.0 hours; whereas, the mean planning time for the remaining battle staff members ranges from 9.7 hours (S3) to 13.3 hours (FSO).

Table 2

Self-reports of time (in hours) spent by battle staff members planning each of three missions.

	BATTLE STAFF MEMBER									
MISSION	CO	XO	S1	S2	AS2	S3	AS3	S4	FSO	**Mean**
1	10	10	2	10	12	10	10	12	10	9.6
2	10	15	2	15	9	11	10/10	6	16	10.4
3	12	12	2	8	16	8	14/10	12	14	10.8
Mean	10.7	12.3	2.0	11.0	12.3	9.7	10.8	10.0	13.3	10.3

These findings leave no doubt that a substantial amount of time was spent planning each of the three missions. The small variability in mean planning time from one mission to another may indicate that the three missions were about equal in complexity and planning difficulty.[9] However, it is probable that the tendency to use all the planning time available also contributed to the small variability in planning time across missions.

Before proceeding, it is important to note that self-reports of time spent planning cannot be treated as a reliable indicator of battle staff members' relative workload during planning. Battle staff members tended to report the number of hours that were required to complete an MDMP step[10] rather than the number of hours they were actively engaged in the tasks that were required to complete the MDMP step. For this reason, planning time is less useful for assessing the relative workload of the battle staff members than other indicators such as (a) battle staff members' workload ratings and (b) the planning task responsibilities of different battle staff members. Both workload ratings and planning task responsibilities are discussed in a later subsection.

[9] This interpretation is supported by battle staff members' ratings of the difficulty of planning each mission. Battle staff members' difficulty ratings are discussed in the next subsection of the report.

[10] The MDMP specifies planning "steps" and "substeps" that must be accomplished [see FM 101-5 (Army, 1997)] when planning a mission. Hereafter, the term "task" will be used when referring to general planning activities. The terms "steps" and "substeps" will be used when discussing the planning activities that were specified by the MDMP.

Planning difficulty. Battle staff members were asked to rate the difficulty of planning each of the three missions relative to planning an operational mission of the same type (Item 2). Responses to the 5-point rating scale range from *much easier* (rating of 1) through *about the same* (rating of 3) to *much more difficult* (rating of 5). The difficulty ratings of each battle staff member who participated in mission planning are shown in Table 3.[11] As stated earlier, two AS3s participated in the planning of Mission 2 and Mission 3. Table 3 shows difficulty ratings for both AS3s; the ratings of the two AS3s are separated by a slash (/).

Table 3

Battle staff members' ratings of the difficulty of mission planning.

	BATTLE STAFF MEMBER									
MISSION	CO	XO	S1	S2	AS2	S3	AS3	S4	FSO	**Mean**
1 (March 3)	4	4	2	5	4	4	4	4	4	3.9
2 (March 5)	3	4	3	5	2	4	4/4[1]	2	--	3.4
3 (March 6)	3	4	2	5	3	4	4/2[1]	4	3	3.4

[1]The two numbers are ratings by the two individuals who served as an AS3 during the planning of the corresponding mission.

The distribution of ratings shows that, as a group, battle staff members judged that the missions were substantially more difficult to plan than comparable operational missions. Specifically, 53.6% of the ratings are 4 (somewhat more difficult), and another 10.7% are 5 (much more difficult). Together, ratings of 2 (somewhat easier) and 3 (about the same) account for only 35.8% of all difficulty ratings. The mean ratings shown in Table 3 indicate that, as a group, battle staff members judged that the difficulty of the three missions was about the same. Although the mean rating for Mission 1 is slightly larger than the mean ratings for Mission 2 and Mission 3, only the CO and the AS2 indicated that Mission 1 was more difficult to plan than the other two missions. More importantly, the battle staff members who were most actively involved in mission planning (XO, S2, and S3) rated mission planning difficulty the same for all three missions. These data provide no evidence that (a) mission planning difficulty differed substantially from one mission to another or (b) mission planning difficulty declined substantially with practice.

Information about the reasons for planning difficulties was provided by responses to Item 3, which asked battle staff members to *Describe ways in which the planning of today's mission was more difficult and the ways it was less difficult than the planning of an operational mission of the same type*. Two reasons for planning difficulty were cited by most of the battle staff members who were actively involved in mission planning.

First, six of the nine battle staff members who were actively involved in mission planning cited "knowledge and skill deficiencies in using digital equipment" as a reason for mission

[11] The BC and ABC occupied the current operations cell when other members of the battle staff were engaged in mission planning. Hence, the battle staff members who served as BC and ABC did not participate actively in mission planning.

planning difficulty. The FSO, the S1, and the S4 did not cite knowledge/skill deficiencies as a reason for mission planning difficulties. The most probable reason that knowledge and skill deficiencies in using digital equipment was not cited by the FSO is that the AFATDS was not operational during the planning of any mission. Responses to other questionnaire items suggest that knowledge/skill deficiencies in using digital equipment was not cited by the S1 and S4 because (a) they were reasonably skilled in using the CSSCS, and (b) a great deal of the logistics data had already been entered into the CSSCS and remained constant throughout a mission.

Second, six of the nine battle staff members who were actively involved in mission planning indicated that planning difficulties stemmed from the duplication of effort required to produce both digital products and conventional (analog) products. This reason was cited by the XO, the S2, the AS2, the S3, one AS3, and the S4. The battle staff members who did not cite duplication of effort as a reason for planning difficulties (CO, S1, and FSO) were not actively involved in the use of digital equipment to produce planning products.

The other reasons cited for planning difficulty tend to be highly related to the battle staff members' responsibilities or to the digital equipment they were required to use. Listed below are the remaining reasons cited for planning difficulty and the battle staff member(s) who cited the reason:

- problems entering graphics and synchronization matrices into the MCS (both AS3s),
- the icons on ASAS are too large (AS2),
- difficulty communicating with brigade (S1, FSO),
- cannot track injured personnel adequately on CSSCS (S1),
- more time is spent getting better products when digital systems are available (CO),
- inadequate time to prepare OPORD (XO),
- the map scales on the MCS and ASAS are far too small for effective planning (S2, S3),
- lack of a weapons system database (S2),
- greater volume of information with digital systems (S1),
- the MCS and ASAS do not provide reliable line-of-sight calculations (CO, S2),
- lack of SOPs, enlisted staff operations, and liaison with higher headquarters (XO), and
- it was necessary to compare manually the information on SALUTE format (size, activity, location, unit, time and equipment) reports and the information on ASAS reports (S2).

Battle staff members cited a relatively small number of reasons why mission planning in the ATCCS was easier than planning a comparable operational mission. Only two reasons were cited by more than one battle staff member. One reason, cited by the CO, the S1, and one AS3, was that "simulator rehearsal is far better than map rehearsal." The second reason, cited by the CO, the XO, the S3, and one AS3, was that the digital equipment (ASAS and MCS) provided an

improved terrain analysis capability. The remaining reasons are listed below along with the battle staff member who cited the reason:

- the environment is less taxing than a field environment (XO),
- the schedule is less taxing than a 24-hour operation (XO),
- there are no difficult security problems to deal with (XO),
- graphics are easy to produce using the digital equipment (AS3),
- digital equipment makes it easier to convey coordinates for a large number of targets (AS2),
- most of the logistics data were already entered into the CSSCS (S4),
- very easy to send intelligence messages to brigade with e-mail system (AS2), and
- it is easier to do time calculations with the digital equipment (SD3).

<u>**Mission realism**</u>. Battle staff members rated the realism of each mission using a 5-point rating scale that varied from *highly unrealistic* (rating of 1) through *moderately unrealistic* (rating of 3) to *highly realistic* (rating of 5). No battle staff member rated any mission as being either highly unrealistic (rating of 1) or highly realistic (rating of 5). Nineteen ratings (59.4%) indicate that the mission being rated was judged to be unrealistic (rating of 2 or 3). The remaining 13 ratings (40.6%) indicate that the mission being rated was judged to be moderately realistic (rating of 4). The frequency of *unrealistic* ratings do not differ significantly from the *realistic* ratings, χ^2 (2, 22) = 1.3, $p > .20$.

When the ratings are pooled across battle staff members, the mean realism rating is nearly identical for the three missions, ranging only from 3.2 to 3.4. When ratings are pooled across missions, the mean ratings of the battle staff members range from 2.3 to 4.0. The mean realism rating is lowest for the S2 (mean = 2.3) and next lowest for the S1 and FSO (mean = 2.7). The mean realism rating is highest for the S4 (mean = 4.0) and nearly as high for the CO, AS3, AS2, and S3 (mean = 3.7). The remaining mean realism ratings are 3 (AS3), 3.3 (XO), and 3.5 (AS3).

In addition to the realism ratings, Item 4 asked battle staff members to list ways the mission was at least moderately unrealistic. The reasons cited for lack of realism are quite similar to the reasons cited for mission planning difficulty. The lack of adequate staff training was cited by the XO, the S2, and the S3 as a reason for lack of mission realism. No other reason for lack of realism was cited by more than one battle staff member. Listed below are the other reasons (other than lack of adequate training) that were cited by each battle staff member who responded to this item:

- CO: the communications were unrealistically reliable;
- XO: lack of SOPs, lack of enlisted staff operations, not a field environment, no 24-hour operations, no security problems, and no environmental problems;
- S1: no direct feed from Forward Area Refueling Point (FARP) to S4, the resupply of Class III and Class IV was unrealistically easy, and no communication with subordinate CSS personnel;

- S2: launched a deep attack with too little intelligence, launched mission despite nearby threats, limited planning time, and missions too complex for skill level;
- AS2: a great deal of duplication of effort in developing both digital and analog products, digital equipment capabilities do not align with MDMP products, the enemy artillery was largely unguarded, and OPFOR was not as rational as an actual opponent;
- S3: inadequate criteria and control measures;
- AS3: no capability to communicate with CAS aircraft;
- S4: unreliable aircraft simulation no Appliqué, and no tasks for S4 after input of data on fuel and ammunition;
- FSO: suitable maps were not available, the rehearsals were not controlled by company commanders, and the grids in the computer did not correspond with the grids on the map; and
- ABC: no requirement to share resources or interact with other units, and the aircraft were exposed to an unrealistically high level of threat.

The data presented above indicate that, as a group, the battle staff members judged the missions to be only moderately unrealistic. However, the reasons for the lack of realism do not appear to be related to the realism of the scenarios for which the missions were planned and executed. Rather, the reasons for lack of realism centered on the prior training of the battle staff members and the lack of NCOs to support the battle staff. So, although battle staff members indicate that the missions were unrealistic in some respects, neither the realism ratings nor the reasons for lack of realism provide compelling evidence that the lack of mission realism was great enough to invalidate the findings of the ATCCS study.

Adequacy of planning resources. Items 5, 6, and 7 asked battle staff members to rate the adequacy of the resources available to perform each of seven MDMP steps. The planning resources included (a) the time available to perform the step (Item 5), (b) the information available to perform the step (Item 6), and (c) the accessibility of the information needed to perform the step (Item 7). Battle staff members who did not participate in an MDMP step checked *did not perform*. Battle staff members who were involved in performing an MDMP step were asked to indicate whether the corresponding resource was *adequate* or *inadequate* to perform the task. Battle staff members rated the adequacy of time, information, and information accessibility for each of the following MDMP steps:

- Receive the Mission,
- Analyze the Mission,
- Develop the COA,
- Analyze the COA (war gaming),
- Compare the COA,
- Approve the COA, and
- Produce the orders.

To gain a clear understanding of battle staff members' views about the adequacy of planning resources, it is necessary to examine their judgments as a function of mission, type of resource, MDMP step, and battle staff position. Throughout this subsection, the percentage

values refer to the percentage of *inadequate* ratings (i.e., the number of *inadequate* ratings divided by the total number of ratings). Not every battle staff member was involved in every MDMP step. Therefore the frequencies vary from one battle staff member to another. Response frequencies for the different battle staff members were normalized to the same base (total responses) prior to computing the χ^2 values that are reported below.

Figure 1 shows the percentage of *inadequate* ratings for time, information, and information accessibility as a function of the mission number. The percentage of *inadequate* responses is not the same for all missions and planning resource types, χ^2 (4, 63) = 36.6, $p<$ .001. Moreover, when responses are pooled across missions and planning resource type, the percentage of *inadequate* responses differ as a function of both mission, χ^2 (2, 63) = 9.9, $p< .01$, and type of planning resource, χ^2 (2, 63) = 19.7, $p< .001$.

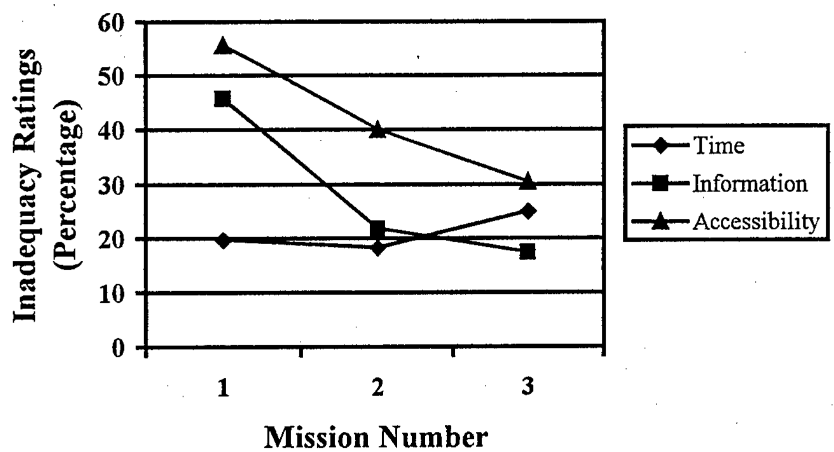

Figure 1. Percentage of *inadequate* ratings as a function of mission number and type of planning resource.

The percentage of *inadequate time* responses do not vary significantly as a function of mission, χ^2 (2, 63) = 0.5, $p> .70$. The percentage *of inadequate information* ratings declined significantly from the first to the third mission, χ^2 (2, 63) = 10.8, $p< .01$. The decline in the percentage of *inadequate accessibility* ratings is significant at the .10 level but not at the .05 level, χ^2 (2, 63) = 4.8, $p< .10$.

The battle staff members' acquisition of knowledge and skill over the three missions is the most probable reason for the decline in *inadequate information* and *inadequate accessibility* responses from the first to the third mission. Apparently, the experience gained over the three missions was not enough to offset the effects of inadequate time for performing some MDMP steps.

Because the mission planning tasks and responsibilities differ substantially from one battle staff member to another (HQDA, 1997), it is reasonable to expect that the adequacy of planning resources would be judged differently by different battle staff members. To examine this relationship, the percentages of *inadequate* ratings were calculated by battle staff position and resource type. The resulting percentage values are shown in Figure 2.

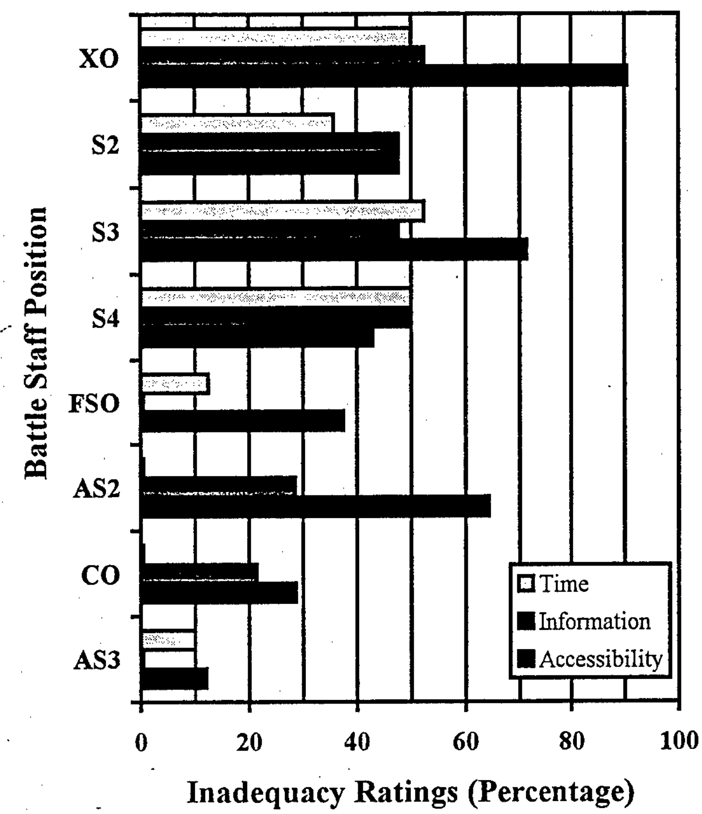

Figure 2. Percentage of *inadequate* ratings as a function of type of planning resource and staff position. Ratings are pooled across the seven MDMP steps.

It should be noted that no ratings are shown in Figure 2 for the BC, the ABC, or the S1. As mentioned earlier, neither the BC nor the ABC was required to participate actively in mission planning. Although the S1 was considered a battle staff member in mission planning, his questionnaire responses indicate that he performed only one MDMP step for one mission. The AS2, the S3, and one AS3 indicated that they were involved in performing all seven of the MDMP steps for each of the three missions. All other battle staff members (CO, XO, S2, S4, and FSO) indicated that they performed three or more of the MDMP steps during every mission.

First, consider the judgments about the adequacy of planning time. The percentage of *inadequate time* responses differ significantly across battle staff members, χ^2 (7, 21) = 32.9, $p<$ .001. The percentage of *inadequate time* ratings is about 50% for the XO, the S3, and the S4; the ratings for the XO, the S3, and the S4 do not differ significantly, χ^2 (2, 21) = 0.02, $p>$ .80. The percentages of *inadequate time* ratings are 23.3% for the S2 and 12.5% or lower for the

remaining battle staff members. The percentage of *inadequate time* ratings is significantly higher for the XO, the S3, and the S4 (as a group) than for the remaining battle staff members (as a group), χ^2 (1, 21) = 6.5, $p < .02$.

Because the XO, the S3, and the S4 must contribute to the performance of many MDMP steps, it is not surprising that about one-half of their time judgments were *inadequate*. Based on the number of MDMP steps to which the S2 must contribute, it would be expected that the percentage of *inadequate time* judgments would have been higher. A possible reason for the S2's responses is that the volume of intelligence information that was available for mission planning was unrealistically low.

An analysis was performed to determine whether the percentage of *inadequate time* ratings was the same for the different MDMP steps. Considering the XO, the S2, the S3, and S4 as a group, it was found that 67.9% of the *inadequate time* ratings are for three steps: Develop the COA, Analyze the COA, and Compare the COA. More will be said later about the adequacy of planning resources for performing the different MDMP steps.

Next, consider battle staff members' judgments about the adequacy of the mission planning information. The percentage of *inadequate information* responses differ significantly across battle staff members, χ^2 (7, 21) = 23.0, $p < .01$. The percentage of *inadequate information* responses is large (47.6% to 52.4%) and not significantly different for the XO, the S2, the S3, and the S4, χ^2 (7, 21) = 0.1, $p > .80$. The percentages of *inadequate information* responses are 28.6% for the AS2, 21.4% for the XO, and 0.0% for both the AS3 and the FSO. Given their roles in many of the MDMP steps, it is not surprising to find that the percentages of *inadequate* ratings are high for the XO, the S2, the S3, and the S4.

Finally, consider the judgments of information accessibility.[12] As is true for time adequacy and information adequacy, the percentage of *inadequate accessibility* responses differ significantly across battle staff members, χ^2 (7, 21) = 18.7, $p < .01$. Figure 2 shows that the percentages of *inadequate accessibility* responses range from a high of 90.5% (XO) to a low of 12.2% (AS3). Figure 2 shows that the percentages of *inadequate accessibility* are quite large (42.8% to 90.5%) for all battle staff members except the AS3 (12.2%) and the CO (28.6%). If the AS3 and CO are excluded, the percentages of *inadequate accessibility* responses for the remaining battle staff members do not differ significantly, χ^2 (6, 21) = 11.0, $p > .05$.

Figure 2 indicates that the XO, the S3, the FSO, and the AS2 judged information accessibility to be more of a problem (higher percentage of *inadequate* responses) than either time availability or information availability. However, the differences are significant only for the FSO, χ^2 (2, 21) = 12.8, $p < .01$, and the AS2 χ^2 (2, 21) = 7.4, $p < .05$.

Figure 3 shows the percentage of *inadequate* ratings as a function of MDMP step and type of planning resource. The percentage values were calculated by pooling the ratings of all battle staff members who participated in mission planning. As is apparent in Figure 3, the

[12] In this study, the only planning information that was not easily accessible was that which could be acquired only through the digital systems. So, judgements of inadequate information accessibility are assumed to be the result of problems encountered in acquiring information through the digital systems.

percentage of *inadequate* responses is not the same for all MDMP steps and all types of planning resources, χ^2 (7, 504) = 44.2, $p < .001$. A χ^2 analysis shows that the number of *inadequate* ratings differ across MDMP steps for time, χ^2 (7, 168) = 34.9, $p < .001$, information, χ^2 (7, 168) = 41.1, $p < .001$, and accessibility, χ^2 (7, 168) = 58.0, $p < .001$.

The percentage of *inadequate* ratings vary as a function of resource type for three MDMP steps: Receive the Mission, χ^2 (2, 72) = 5.6, $p < .02$, Analyze the Mission, χ^2 (2, 72) = 8.7, $p < .01$, and Develop the COA, χ^2 (2, 72) = 4.2, $p < .05$. For the remaining MDMP steps, the percentage of *inadequate* responses do not differ significantly ($p \geq .05$) across the three resource types.

For the most part, the data shown in Figure 3 are self-explanatory. However, three findings deserve a brief comment. First, it is worth noting that for every MDMP step the percentage of *inadequate accessibility* responses is larger than the percentage of *inadequate time* responses and the percentage of *inadequate information* responses.

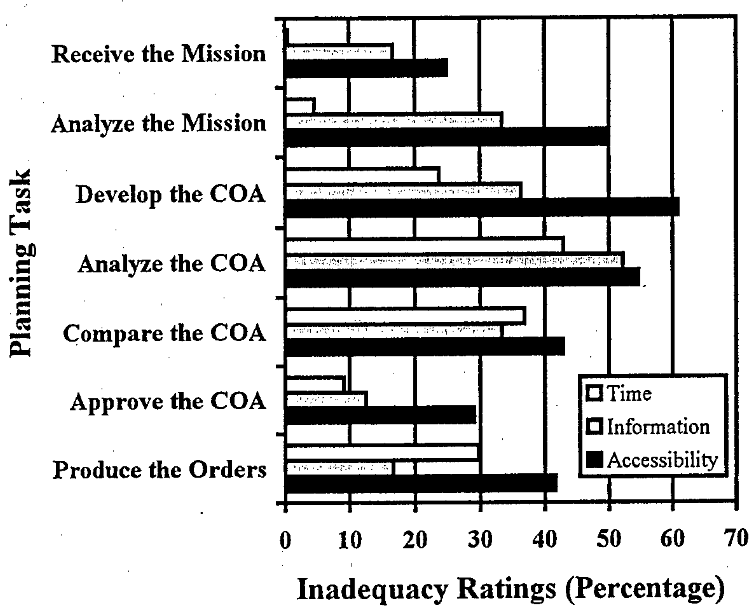

Figure 3. Percentage of *inadequate* ratings as a function of type of planning resource and MDMP step. Ratings are pooled across all battle staff members who were involved in mission planning.

Although not all of the differences are statistically significant, this finding is consistent with the observation made earlier that inadequate accessibility of information was a somewhat greater problem than either inadequate time or inadequate information.

Second, it is worth noting that the percentages of *inadequate time* responses are relatively high for the MDMP steps Develop the COA (23.8%), Analyze the COA (42.9%), Compare the COA (36.8%), and Produce the Orders (29.2%). Because of the number of substeps that must be completed, it is not surprising the percentages of *inadequate time* responses are highest for the

tasks Develop the COA, Analyze the COA, and Compare the COA. However, it was surprising to find a relatively large percentage of *inadequate time* responses for the MDMP step Produce the Orders. Because producing orders is not nearly as complex and labor intensive as some of the other MDMP steps, it is possible that the battle staff members used most of the available time performing other MDMP steps and left an inadequate amount of time for the final step: Produce the Orders. In short, it seems likely that a time management problem was the reason for the *inadequate time* responses for the MDMP step Produce the Orders.

Third, as would be expected, the percentages of *inadequate information* ratings are relatively high for all the MDMP steps for which the compilation of information is a critical requirement: Analyze the Mission (33.3), Develop the COA (36.4%), Analyze the COA (52.2%), and Compare the COA (33.3%). The reasons for the small but nontrivial percentages of *inadequate information* responses for the other three MDMP steps are not known for certain. The *inadequate information* responses for the MDMP step Receive the Order (16.7%) may be due to the problems encountered in receiving the OPORD on the MCS (on Day 1). The *inadequate information* responses for the MDMP steps Approve the COA (12.5%) and Produce the Orders (16.7%) may be due to the problems encountered in using the digital systems to produce briefing materials and to produce written orders.

Workload level. An item asking battle staff members to rate their level of workload was included on the questionnaire with the full realization that responses to such items have not proved to be highly reliable or highly sensitive measures of mental workload. Unfortunately, the methods that are known to provide reliable methods of workload were judged too time consuming and too obtrusive for this study. For a review of subjective workload assessment techniques, see (Christ et al., 1993; Lysaght et al., 1989; Schmidt and Nicewonger, 1988; Wierwille, Rahimi, and Casalli, 1985). For this reason, it is important to exercise caution in interpreting battle staff members' workload ratings. In particular, the battle staff members' workload ratings reported below should not be used to draw inferences about the presence or absence of excessive workload (i.e., mental overloads) for individual battle staff members. However, it seems safe to use the ratings to draw inferences about relative workload from one mission to another and from one MDMP step to another.

Item 8 asked battle staff members to rate the highest level of workload they experienced when performing each of seven MDMP steps. Battle staff members used a rating scale with four levels: Too Low, Moderate, High, and Very High. Battle staff members were asked to place a check in a separate box if they were not involved in performing the corresponding MDMP step. Because some battle staff members were not involved in mission planning, a total of 198 workload ratings resulted from the three missions, the seven MDMP steps. The distribution of ratings for the total sample is shown below.

- Too Low = 3.5%
- Moderate = 51.5%
- High = 31.9%
- Very High = 13.1%

The results of a χ^2 test indicate that the four rating values were <u>not</u> selected with equal frequency, χ^2 (3, 198) = 96.9, p< .001. An analysis of the ratings across missions showed no change in the relative frequency across missions for the *moderate* rating, χ^2 (2, 66) = 2.3, p> .05, and the *high* rating, χ^2 (2, 66) = 1.0, p> .05. The frequency of *too low* ratings declined significantly from Mission 1 (10.6%) to Mission 2 (0.0%), χ^2 (2, 66) = 14.0, p< .001. The frequency of *very high* ratings also declined from Mission 1 (21.2%) to Mission 3 (8.7%), but the decline failed to reach the .05 level of significance, χ^2 (2, 66) = 5.1, p< .10. The decline in both *too low* and *very high* ratings suggests that the experience gained in Mission 1 enabled battle staff members to become more proficient at distributing the work such that no battle staff member had too little or too much to do.

Too low workload ratings are important because they suggest that a battle staff member may be underutilized. Only 8 of the 196 workload ratings are *too low* and all *too low* workload ratings were given by three battle staff members: the XO, the BC, and the S1. The data presented below show that the XO clearly was not underutilized. The BC was not actively involved in the planning process, so his *too low* ratings indicate only that his workload was low for the few MDMP steps in which he participated. The S1 was an active member of the planning team, so his *too low* workload ratings suggest that he was underutilized during mission planning. This conclusion is supported by the fact that the S1 gave no workload rating higher than *moderate*. The reasons for the S1's under-utilization during mission planning are not known.

The distribution of *high* and *very high* workload ratings across battle staff members provides an indication of unequal and, perhaps, inefficient distribution of work among battle staff members. Reference to FM 101-5 (HQDA, 1997) shows that battle staff members vary widely in the number of MDMP steps and substeps to which a battle staff member is expected to contribute. In short, an unequal distribution of mission planning work may be dictated by doctrine. This conclusion is supported by Figure 4, which shows the percentage of *high* ratings, the percentage of *very high* ratings, and the combined percentage of *high* and *very high* ratings for the battle staff members who were actively involved in mission planning.

Analyses were conducted to test the null hypothesis that the percentages of *high* workload ratings and the percentages of *very high* workload ratings are the same for all battle staff members. Statistically significant differences among battle staff members were found for the percentages of *high* ratings, χ^2 (6, 141) = 38.5, p< .001, the percentages of *very high* ratings, χ^2 (6, 141) = 31.0, p< .001, and the combined percentages (*high* plus *very high* ratings, χ^2 [6, 141] = 69.4, p< .001).

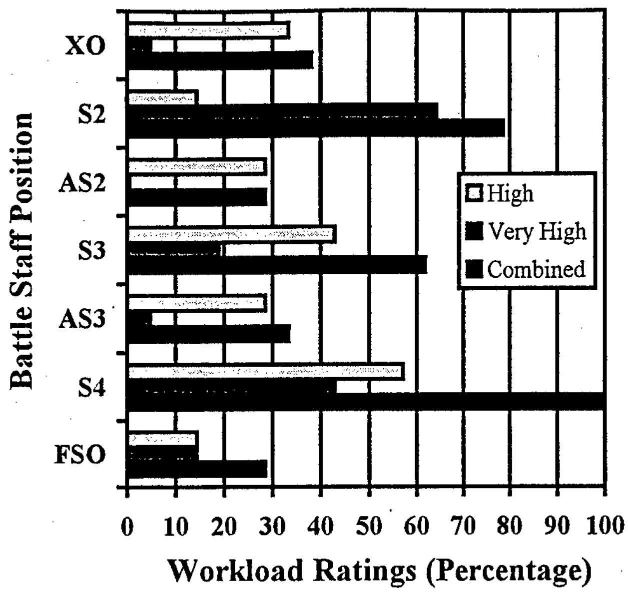

Figure 4. Percentage of *high*, *very high*, and combined (*high* plus *very high*) workload ratings for seven battle staff members.

Figure 4 suggests that the battle staff members can be separated into two groups with respect to the combined percentages of *high* and *very high* ratings. This grouping is supported by the results of a χ^2 analysis. The combined percentages for the S2, the S3, and the S4 do not differ significantly, χ^2 (2, 58) = 0.4, $p > 0.90$. Similarly, the combined percentages for the XO, the AS2, the AS3, and the FSO do not differ significantly, χ^2 (4, 85) = 0.3, $p > 0.90$. However, the mean combined percentage for the S2, the S3, and the S4 is significantly larger than the mean combined percentage for the XO, the AS2, the AS3, and the FSO, χ^2 (2, 141) = 4.0, $p < .05$.

The data shown in Figure 4 suggest that work was not distributed uniformly among the battle staff members. Because of the large number of MDMP substeps in which they are involved, it is not surprising that the combined percentages of *high* and *very high* workload ratings are relatively large for both the S2 and S3. It is interesting to note that the combined percentages for the S2 and S3 are substantially larger than the combined percentages for their assistants, the AS2 and AS3. Apparently, the S2 and the S3 were unable or unwilling to off-load a sufficient amount of their planning tasks to their assistants. It was surprising to find that every one of the S4's workload ratings are *high* or *very high*; the reasons for *high* workload level reported by the S4 are not known.

An analysis was conducted to test the null hypothesis that the percentage of responses selecting each workload rating was the same for all MDMP steps. It was found that that the percentage of *low* workload ratings do not vary as a function of MDMP step, χ^2 (6, 8) = 9.1, $p >$ .20. However differences vary as a function of MDMP step for *moderate* ratings, χ^2 (6, 99) = 71.5, $p < .001$, *high* ratings, χ^2 (6, 99) = 65.5, $p < .001$, and *very high* ratings χ^2 (6, 99) = 21.4, $p <$ .001. Figure 5 shows the percentage of *high* ratings, *very high* ratings, and combined *high* and *very high* ratings for each MDMP step.

Of the seven MDMP steps, the reports of heavy workload were most frequent for the MDMP step Analyze the COA. Combined, the *high* and *very high* ratings account for 86.3% of all workload ratings given for this step. The combined percentages of *high* and *very high* workload ratings are also quite large for the steps Analyze the Mission (40.0%), Develop the COA (56.5%), Compare the COA (50.0%), and Produce the Orders (50.0%). Although the combined percentages for these five MDMP steps differ by 45.4%, the differences are not large enough to reach statistical significance at the .05 level, χ^2 (4, 137) = 4.5, p> .30.

By comparison, the combined percentages of *high* and *very high* workload ratings are relatively small for the MDMP steps Receive the Mission (20.0%) and Approve the COA (20.0%). The mean combined percentage for the MDMP steps Receive the Mission and Approve the COA (20.0%) differ significantly from the mean combined percentage for the other five MDMP steps (56.0%), χ^2 (2, 196) = 5.4, p< .05.

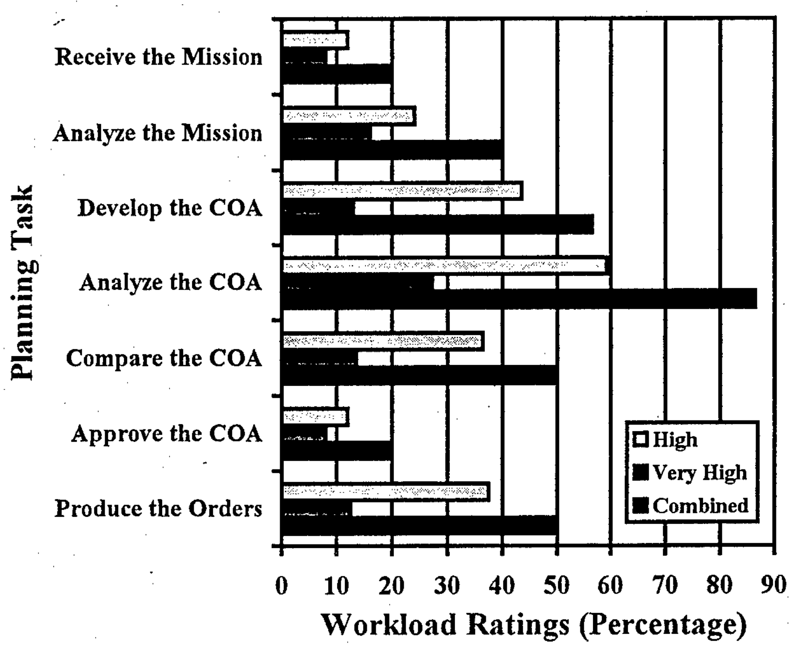

Figure 5. Percentages of *high*, *very high*, and combined (*high* plus *very high*) workload ratings for seven MDMP steps.

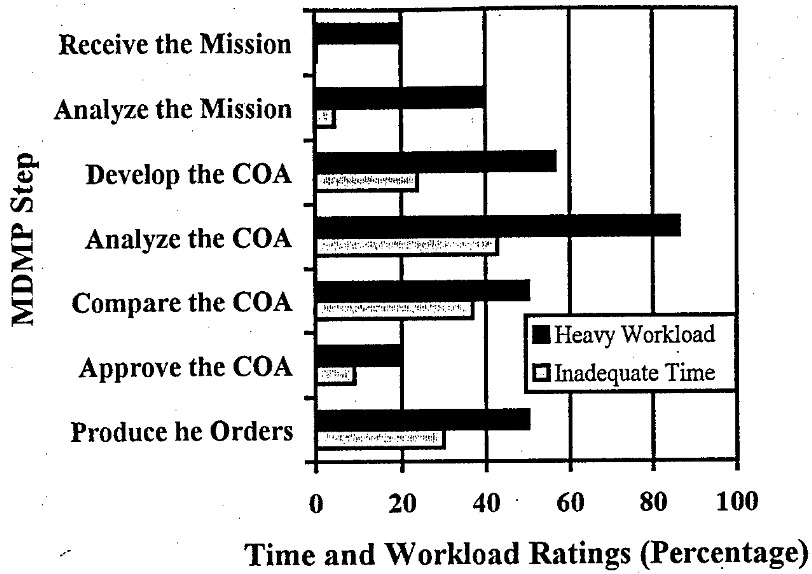

Figure 6. Relationship between the percentage of *inadequate time* ratings and heavy (*high* plus *very high*) workload ratings.

High workload can result from task complexity, time constraints, or a combination of the two. If time constraint was the main contributor to battle staff members' workload, the percentage of high workload ratings should be closely related to the percentage of *inadequate time* ratings. Figure 6 shows the percentage of *inadequate time* ratings and the percentage of heavy workload ratings (*high* plus *very high* workload) for each of the MDMP steps. A Spearman rho coefficient (Guilford and Fructer, 1978) is significant at the .05 level, r (6 df) = 0.9, $p < .05$, indicating that the *inadequate time* ratings are highly related to the heavy workload ratings.

Although the two ratings are closely related, the percentage of heavy (*high* plus *very high*) workload ratings is considerably larger than the percentage of *inadequate time* ratings for every MDMP step. The differences range from a low of 13.2% (Compare the COA) to a high of 43.5% (Analyze the COA). These differences between the two types of ratings may reflect the extent to which factors other than time constraints contributed to battle staff members' workload. This interpretation is supported by the finding that the largest differences between *inadequate time* ratings and heavy workload are found for the three MDMP steps that require the most experience and analytic skills: Analyze the COA (difference = 43.5%), Analyze the Mission (difference = 35.5%), and Develop the COA (difference = 32.7%).

<u>Planning errors and oversights</u>. For each of seven MDMP steps, battle staff members were asked if errors or oversights were made in performing the step. Battle staff members who responded affirmatively were asked to identify each error or oversight that was made and to identify the step in which it was made. The percentages of affirmative responses for each of the three missions are shown below. Although the percentage of affirmative responses declined from the first to the third mission, the decline was not great enough to reach statistical significance at the .05 level, χ^2 (2, 60) = 3.3), $p > .05$.

- Mission 1 = 43.3%
- Mission 2 = 29.1%
- Mission 3 = 25.5%

The percentages of affirmative responses vary substantially among the battle staff members who participated actively in mission planning, χ^2 (7, 21) = 61.7, p< .001. Figure 7 shows the percentage of affirmative responses for each of the seven battle staff members who was an active battle staff member in mission planning. The percentages

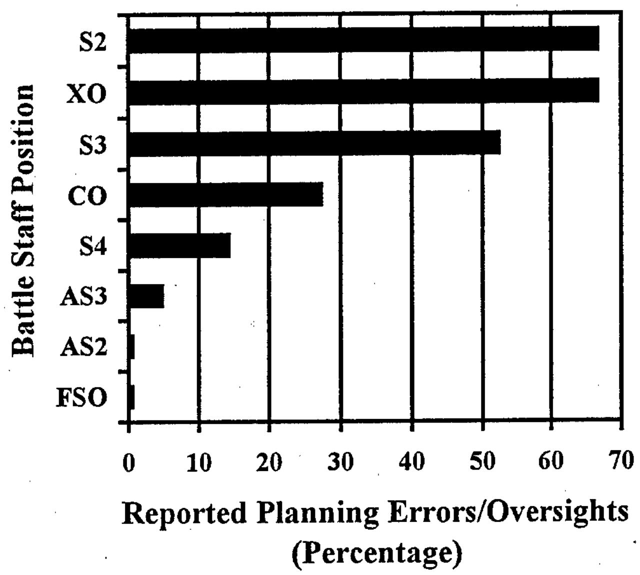

Figure 7. Self-reported planning errors/oversights for the battle staff members who were actively involved in mission planning.

shown in Figure 7 are based on the total number of responses made for the three missions and the seven MDMP steps (n = 21).

The frequencies of affirmative responses are relatively high, but not statistically different, χ^2 (2, 21) = 0.5, p> .8, for the three battle staff members who participated in the largest number of MDMP steps and substeps: the XO (66.7%), the S2 (66.7%), and the S3 (52.4%). As a group, the XO, the S2, and S3 reported a larger number of planning errors and oversights than the remaining battle staff members (as a group), χ^2 (2, 21) = 8.1, p< .01. The percentage of affirmative responses is relatively low for the CO (27.3%), the AS2 (0.0%), the AS3 (4.8%), the S4 (14.3%), and the FSO (0.0%); the percentages do not differ significantly among these battle staff members, χ^2 (3, 21) = 6.7, p> .10.

The larger number of planning errors and oversights reported by the XO, S2, and S3 does not reflect a lessor level of experience or skill than the remaining battle staff members. The XO, S2, and S3 were at least as experienced as all other battle staff members except the CO. Rather, the large number of reported planning errors/oversights is probably due to the fact that the XO,

S2, and S3 were in a better position to recognize planning errors and oversights because of their involvement in most of the MDMP steps and substeps.

The percentages of affirmative responses are shown by MDMP step in Figure 8. The percentages in Figure 8 are based on the responses made for three missions by the eight battle staff members who participated actively in mission planning: CO, XO, S2, AS2, S3, AS3, S4, and FSO ($n = 21$). Although the range of percentage values range from a low of 21.1% (Receive the Mission and Approve the COA) to a high of 66.7% (Develop the COA), the percentages do not differ significantly, χ^2 (6, 21) = 6.9, $p > .5$.

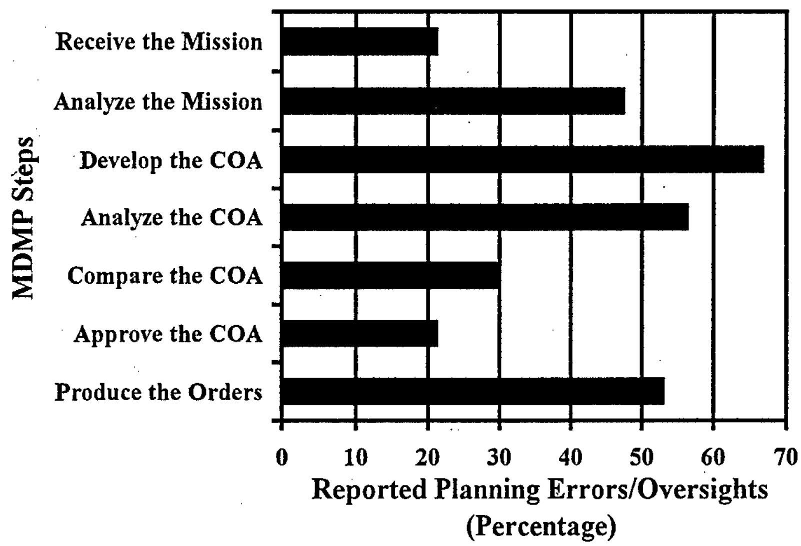

Figure 8. Self-reported planning errors/oversights for each of the seven MDMP steps.

Although the number of reported planning errors and oversights does not differ significantly from one MDMP step to another, the absolute sizes of the percentage values for some MDMP steps are worthy of comment. First, the number of planning errors and oversights reported for the MDMP steps Receive the Mission and Produce the Orders are surprisingly large. Although the reasons for the large percentage values are not known, it is probable that the errors made in Receiving the Mission and Producing the Orders were technical rather than conceptual. Comments by the battle staff members indicate that they encountered difficulties in using the digital systems to receive the OPORD and to prepare the written orders for a mission. Most of the remaining MDMP steps are dependent on both conceptual knowledge and skill in using the digital systems. Hence, it seem likely that both conceptual errors and technical errors contributed to the errors and oversights reported for the MDMP steps Analyze the Mission, Develop the COA, Analyze the COA, and Compare the COA. Data presented in the next subsection support the above speculation that both conceptual and technical errors and oversights contributed to the battle staff members' reports.

Although all battle staff members were requested to describe the planning errors and oversights they observed, only a few battle staff members provide meaningful descriptions.

Listed below are the errors/oversights described on the questionnaire. The battle staff member who described the error is shown in parentheses at the end of each description.

- The doctrinal MDMP was modified to accommodate the limited capabilities of the digital systems. This resulted in an incomplete, spotty analysis. (S2, AS2)
- Terrain analysis errors occurred because of the lack of a large-scale map. Errors also were made in performing line-of-sight analyses because of the lack of a large-scale map and limitations in the digital systems. (CO, S2)
- Because of digital system limitations, errors were made in producing the modified combined obstacle overlay (MCOO). (AS2)
- Many MDMP steps were not performed adequately or were not performed at all (e.g., Develop the COA, Analyze the COA, and Compare the COA). (XO, S2)
- The attack battle maneuver was not doctrinal. (S3)
- Did not develop a CSAR plan. (S3, S4)
- Did not do adequate contingency planning. (S3)
- Developed and used nonstandard graphics. (S3)
- Did not provide command guidance early enough in the planning process. (CO)
- Did not recognize the need for a jump FARP. (AS3)

Training deficiencies. Item 10 asked battle staff members to indicate, for each MDMP step, whether or not lack of familiarity with the digital system made it more difficult to perform the step. For each of six MDMP steps,[13] Item 14 asked battle staff members to indicate whether their prior training was adequate for performing the step. Battle staff members' prior training influenced their responses to both items. Deficiencies in digital system training influenced battle staff members' responses to Item 10, while training deficiencies in general influenced their responses to Item 14, including deficient training on the digital systems. Because of the similarity between Item 10 and Item 14, battle staff members' responses to the two items are discussed together. The percentage values presented below refer to the percentage of *inadequate* responses: *inadequate familiarity* with the digital systems and *inadequate prior training* in general.[14]

Table 4 shows the percentage of *inadequate familiarity* responses and the percentage of *inadequate prior training* responses for each of the three missions. The percentages of *inadequate familiarity* responses range from 53.3% to 69.1%. Although the percentage of *inadequate familiarity* responses declined 24.5% from Mission 1 (69.1%) to Mission 2 (44.6%), the percentages for the three missions do not differ significantly, χ^2 (2, 68) = 3.8, $p > .10$. The percentage of *inadequate prior training* responses is relatively uniform across missions, varying from 48.2% to 56.8%. The percentages of *inadequate prior training* responses do not differ significantly across the three missions, χ^2 (2, 56) = 0.1, $p > .90$. The data shown in Table 4

[13] The MDMP step Produce the Orders was inadvertently excluded from the list of MDMP steps presented in Item 14.

[14] Item 10 asked battle staff members if lack of familiarity with the digital systems made it more difficult to perform a task. A "yes" response was interpreted to mean that familiarity with the digital systems was inadequate. A "no" response was interpreted to mean that familiarity with the digital systems was adequate. It is possible that some of the "no" responses indicated that the digital systems were not used to perform the planning task, so lack of familiarity with them did not influence task performance.

suggest that the experience gained during the three missions did little to offset the deleterious effects of inadequate familiarity with the digital systems and inadequate prior training in general.

Table 4

Percentage of *inadequate familiarity* responses and *inadequate prior training* responses for each of three missions.

Type of Training Deficiency	**Mission Number** 1	2	3
Inadequate Familiarity with Digital Systems (n = 68)	69.1%	44.6%	53.3%
Inadequate Prior Training, General (n = 56)	52.1	48.2	56.8%

Note. The numbers (n) represent the total number of responses for a mission, pooled across MDMP steps and battle staff members.

The percentages of *inadequate familiarity* responses and the percentages of *inadequate prior training* responses are shown for individual MDMP steps in Figure 9. The MDMP step Produce the Orders was inadvertently excluded from Item 14. Although the percentage of *inadequate familiarity* responses range from a low of 28% (Receive the Mission) to a high of 75.0% (Develop the COA), the differences in percentages across MDMP steps are not statistically significant, χ^2 (6, 68) = 5.2, $p>$ .40. The range of percentage values is slightly less for the *inadequate prior training* responses (from 38.5% to 75.0%) and, again, the differences in percentages across MDMP steps are not statistically significant, χ^2 (5, 56) = 4.8, $p>$ .30.

Although neither *inadequate familiarity* responses nor *inadequate prior training* responses differ significantly across MDMP steps, the absolute sizes of several percentage values are worthy of brief comment. A relatively large percentage of *inadequate* responses would be expected for the four MDMP steps that require the largest number of substeps and most complex analyses (viz., Analyze the Mission, Develop the COA, Analyze the COA, and Compare the COA). However, it must be considered surprising that (a) the percentages of *inadequate familiarity* responses for these four MDMP steps are no less than 54.5%, and (b) the percentages *of inadequate prior training* responses are no less than 46.2%. A substantially smaller percentage of *inadequate* responses would be expected for the MDMP steps that require fewer substeps and that require a lessor amount of complex analyses to perform. However, Figure 9 shows that the percentages of *inadequate familiarity* responses and the percentages of *inadequate prior training* responses are quite large for the MDMP steps Receive the Mission and Approve the COA; the percentage of *inadequate familiarity* responses also is quite large for the MDMP step Develop the Orders. Problems encountered in using the digital systems to perform largely clerical tasks may account for the large percentages of *inadequate familiarity* responses for these three MDMP steps. However, no reasons can be given for the large percentages of *inadequate prior training* responses given for the MDMP steps Receive the Mission and Approve the COA.

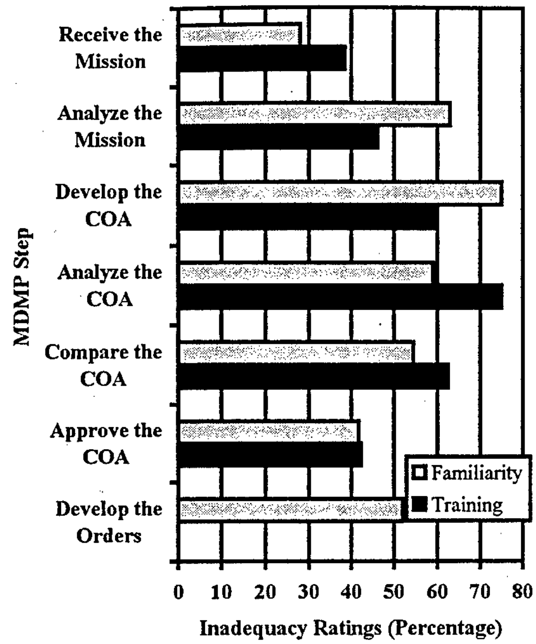

Figure 9. Percentages of *inadequate familiarity* responses and *inadequate prior training* responses for each MDMP step.

Figure 10 shows the percentage of *inadequate familiarity* responses and the percentage of *inadequate prior training* responses for each of the battle staff members who were active battle staff members in mission planning. The FSO failed to respond to Item 10 and Item 14 because of a misinterpretation, so was not included in Figure 10. The percentages of *inadequate familiarity* responses differ significantly across battle staff members, χ^2 (6, 21) = 35.4, p< .001. Figure 10 shows that the battle staff members can be divided into two groups based upon the percentages of *inadequate familiarity* responses. The low percentage group has only two members, the CO (27.3%) and the AS3 (28.6%). The high percentage group includes all other members of the battle staff: the XO (66.7%), the S2 (65%), the AS2 (50%), the S3 (76.2%), and the S4 (92.9%). The percentages of members of the high percentage group do not differ significantly, χ^2 (4, 21) = 2.98, p> .30. However, the percentages of *inadequate familiarity* responses are significantly larger for the high group than the low group, χ^2 (1, 21) = 3.8, p< .05. With one exception—the AS3—the percentage of *inadequate familiarity* responses appear to be related to the battle staff member's use of the digital system. The low percentage of *inadequate familiarity* responses by the AS3 may be due to his higher level of familiarity with the digital system or to his use of the digital systems only for tasks he knew how to perform.

The percentages of *inadequate prior training* responses differ significantly across battle staff members, χ^2 (6, 21) = 25.4, p< .001. However, if the AS3's percentage is excluded, the percentages of *inadequate prior training* responses for the remaining members of the battle staff do not differ significantly, χ^2 (5, 21) = 2.83, p> .70. Excluding the AS3, the percentages of *inadequate prior training* responses range from a low of 66.7% to a high of 100%. The data shown in Figure 10 suggest that inadequate prior training adversely influenced the performance of every battle staff member except the AS3. The prior training of the AS3 was similar to that of

other staff members. Therefore the low percentage of *inadequate prior training* responses almost certainly is due to the fact that the AS3 was assigned less demanding tasks than the other members of the battle staff.

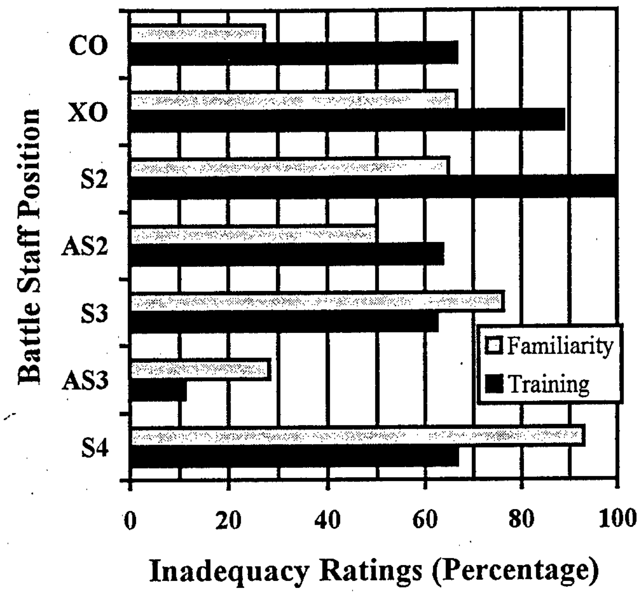

Figure 10. Percentage of *inadequate familiarity* responses and *inadequate prior training* responses for each battle staff member who was an active battle staff member in mission planning.

Both Item 10 and Item 14 asked battle staff members to describe specific knowledge and skill deficiencies that degraded their mission planning performance. Every battle staff member stated that they needed more training on the function and use of the digital systems and on working together as a team. The additional hands-on "train-up" time recommended by battle staff members ranges from two days to two weeks. None of the battle staff members' written comments indicate a need for additional training on the MDMP in general or additional training on how to perform a specific MDMP step. Similarly, battle staff members' written comments shed no new light on the specific problems that directly resulted from inadequate familiarity with the digital systems or from inadequate prior training. The written comments for Items 10 and 14 mirror those listed above in the subsection that discusses mission planning errors and oversights.

Defining TTP. There are many Army publications, mostly field manuals, which purport to document TTPs for some particular organizational unit or a particular activity. TTP is a commonly used term and generally assumed to have an intrinsic and commonly understood meaning. This assumption is incorrect. The authors have been unsuccessful in extracting a formal definition of TTP from Army doctrine. Nor is there any known consistent format for documentation of TTP. In the absence of a definition of the term TTP as a whole it is logical to seek definitions of the component terms. The term tactics is defined by the Department of Defense (Joint Chiefs of Staff, 1994) as: "1. The employment of units in combat. 2. The ordered arrangement and maneuver of units in relationship to each other and/or to the enemy in order to fully utilize their full potentialities". A general definition of tactics (Webster's New

World Dictionary of the American Language) is: "the science of arranging and maneuvering military or naval forces in action or before the enemy, esp. (as distinguished from STRATEGY) with reference to short-range objectives". The same reference defines technique as: "the method of procedure (with reference to practical or formal details), or way of using basic skills, in rendering an artistic work or carrying out a scientific or mechanical operation". Technique does not appear to be defined in military publications. Procedure is doctrinally defined (Joint Chiefs of Staff, 1994) in this manner: "A procedure begins with a specific, documentable event that causes an activity to occur. The activity must produce a product that normally affects another external organization. Frequently, that product will be the event that causes another procedure to occur. It is important to recognize that a procedure determines 'what' an organization must do at critical periods but does not direct 'how' it will be done." The general definition (Webster's New World Dictionary of the American Language) is: "the act, method or manner of proceeding in some process or course of action; esp., the sequence of steps to be followed".

Aside from the remarkable degree of circularity of this last definition, there appears to be considerable overlap in the meanings of the three component terms. This leads us to a question as to whether they are distinct concepts or synonyms. The conglomerate term, *tactics, techniques and procedures* provides a satisfying degree of alliteration and meter that may contribute to its common use, perhaps to refer to a single class of behavioral prescriptions relating to the execution of military operations. Under an assumption that the component terms are distinct, though overlapping, concepts then their interrelationships require definition in order to clarify the meaning of the composite. It seems evident that the components all refer to prescriptions for classes of action. It is possible that these classes of action could be parallel, sequential or hierarchically related. This last relationship appears to best fit the use of the component terms and the applications in which the composite term is employed. It is also possible that there are two coexisting relationships among these terms. Two terms may be parallel concepts that contribute to one higher level term.

The core concept of the component term *tactics* appears to be *arrangement* (maneuvering may be considered a time-varying extension of arrangement). In this sense it is more distinct from technique and procedure than those two are from each other. Tactics appears to be the top-level component, to which the others contribute. It appears to involve the spatial and temporal relationships of the major functional elements of mission execution (e.g. two scout aircraft, a company of attack aircraft and a TOC). The core concept of *procedure* appears to be a combination of *manner* and *sequence*. Therefore procedure may entail specification of, for example, mission phases and tasks, and their spatial and temporal interrelationships. The core concept of *technique* appears to be a combination of *method* and *skill*. Therefore technique may refer, for example, to the methods by which control procedures are ensured or communication transactions are completed.

We propose that the interrelational structure of the components of the term TTP is hierarchical where techniques comprise procedures which comprise tactics, despite the violence this does to the poetic aspects of the composite term.

Inadequate TTPs. Item 11 asked battle staff members to indicate whether or not the TTPs they employed were inadequate for performing the MDMP steps and, if so, to identify the

TTPs that were inadequate. For every MDMP step, at least 42% of the responses indicate that the TTPs were considered inadequate for performing the step. The percentages of *inadequate TTP* responses were about 60% for the steps Develop the COA, Analyze the COA, and Compare the COA.

The percentages of *inadequate TTP* responses range widely (from 0.0% to 100%) from one battle staff position to another, but the percentages are uniformly high for the battle staff members who were most actively involved in mission planning (XO = 100%, S2 = 100%, S3 = 76%, S4 = 100%, and FSO = 100%).

The battle staff members' written descriptions of inadequate TTPs provided very little useful information about specific TTPs that were inadequate or about new TTPs that were needed. Although every battle staff member provided a written response for Item 11, the responses describe digital system design deficiencies or training deficiencies rather than TTPs. The reasons why battle staff members described problems other than TTPs are not known. One possible reason is that battle staff members received no training on TTPs that are needed for operating effectively in a digital TOC. This explanation is supported by the S2's comment that he could not assess the adequacy of existing TTPs because he had no idea what they were. A second possible reason is that the term TTP appears to have been poorly understood by members of the battle staff.

All of the problems identified in the battle staff members' written comments for Item 11 have been mentioned earlier in the discussions of responses to other questionnaire items.

Need for additional automation. Battle staff members were asked to indicate if more automation is needed to perform an MDMP step with sufficient accuracy, comprehensiveness, or speed. For the seven MDMP steps, between 24.0% and 43.5% of the responses indicate that more automation is needed to perform the step. However, most of the suggestions for additional automation are aimed at improving performance on two or more MDMP steps. Summarized below are the recommendations that generated most of the responses indicating that increased automation is needed.

- The CO identified a need for an easy way to make annotations on digital displays. Specifically, the CO suggested the development of a "John Madden pen" that would enable him to quickly sketch his vision onto the MCS, thereby, providing the basis for the subsequent development of the COA graphics.
- The CO suggested that a system should be developed whereby designating (i.e., double clicking) an enemy vehicle icon will cause the system to search an OPFOR database and to display information about the vehicle.
- The XO and the S2 suggested that more automation is needed to eliminate the requirement for manual entry of spot reports and other information that already is in digital form in the same or another system. In particular, it should not be necessary to enter manually the same information into both the ASAS and the MCS.
- The XO, the S2, and the S3 suggested that more automation is needed to facilitate the creation and transfer of graphics. The system should provide for the automatic distribution of updated graphics.

This subsection ends with comments about the practical limitations of using observers to gather useful information about mission planning problems, especially mission planning errors and oversights.

Time spent on MDMP steps. The mission planning observers recorded the amount of time spent on each of six MDMP steps. The times recorded for Mission 1 and Mission 3 are shown in Table 5. The last row shows the total time spent on all six MDMP steps. The right-hand column shows the mean time for the six MDMP steps, individually and collectively.

Considerably more time was spent planning Mission 1 (6.0 hours) than Mission 3 (3.7 hours). With only one exception, the time spent on the individual MDMP steps was greater for Mission 1 than for Mission 2; the time spent evaluating the COA was 23 minutes longer for Mission 3 than for Mission 1. The largest difference is found for the step Analyze the Mission. Over two hours were spent analyzing Mission 1, and only 18 minutes were spent analyzing Mission 2. For all other MDMP steps, the difference in the time spent accomplishing the step ranges from 10 minutes (Receive the Mission) to 40 minutes (Approve the COA).

Because of the experience gained in planning Mission 1 and Mission 2, the efficiency of the planning team undoubtedly was greater for Mission 3 than for Mission 1. However, increased efficiency cannot be considered the only cause or even the primary cause of the decline in the planning time from Mission 1 to Mission 3. The differences in the time spent on the MDMP steps can be attributed in large part to differences in the types of missions[15] that were being planned and differences in the total amount of time available for mission planning. The confounding of experience with mission type make it impossible to assess the independent effects of increased efficiency and mission type on mission planning time.

Table 5

Mission planning times recorded by the mission planning observer.

	Planning Time (in Minutes)		
MDMP Step	**Mission 1**	**Mission 3**	**Mean**
Receive the Mission	20	10	15
Analyze the Mission	130	18	74
Develop the COA	30	60	45
Evaluate the COA	60	83	71.5
Compare the COA	60	30	45
Approve the COA	60	20	40
Total	360	221	290.5

The total planning time recorded by the observer was considerably less than the total planning times reported by battle staff members (see Table 2). Battle staff members indicated

[15] It will be recalled that the purpose of the first mission planning session was to plan a deliberate attack, and the purpose of third session was to plan a hasty attack.

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that at least 10 hours were spent planning both Mission 1 and Mission 3, which is considerably more than the total times shown in Table 5 (6.0 hours for Mission 1 and 3.7 hours for Mission 3). One reason for the differences is that Table 2 includes the time required to Produce the Orders, but Table 5 does not. The step Produce the Orders was inadvertently left off of the observer's data collection form.

A second reason for the time differences is that some battle staff members spent time after regular duty hours on mission planning activities. The after-hours mission planning activities were unscheduled but not unexpected. Nevertheless, there was no opportunity to compile information about the battle staff members who engaged in after-hours mission planning or the MDMP steps on which they worked. The information gained through unstructured interviews suggests that the XO, the S2, and the S3 engaged in after-hours mission planning; however, no attempt was made to question them about the work they performed during the after-hours mission planning sessions.

A third reason for the time differences is that battle staff members reported elapsed time, and the observer reported only the time spent working. The observer did not include lunch breaks or other breaks taken during the time an MDMP step was being performed. In addition, the observer did not include the time that transpired between the completion of one MDMP step and the start of the next step. For all of the above reasons, the times shown in Table 5 are accurate estimates of the time that the planning team spent working on the individual MDMP steps that are listed. However, the total times shown in Table 5 underestimate the time spent planning the entire mission, because it does not include the time spent producing the orders.

Battle staff members' participation in MDMP substeps. Mission planning observers recorded each MDMP substep that was accomplished and recorded the battle staff members who contributed to the accomplishment of each substep. The data compiled by the mission planning observers show that some amount of effort was expended on most of the MDMP substeps that are specified by doctrine. Some amount of effort was spent on nearly 86% of all substeps during the planning of Mission 1 and on about 75% of all substeps during the planning of Mission 3.

Of the 28 substeps that were not performed when planning Mission 3, 21 are substeps for the MDMP step Evaluate the COA. For all other MDMP steps, the number of substeps not performed was about the same for Mission 1 and Mission 3. Although about one-half of the substeps were performed when evaluating the COA for Mission 3, battle staff members spent more time evaluating the Mission 3 COA (83 minutes) than they spent evaluating the Mission 1 COA (60 minutes). These findings suggest that battle staff members accommodated to the reduced planning time available for Mission 3 by (a) eliminating substeps from the MDMP step Evaluate the COA and (b) reducing the amount of time spent on all MDMP steps except Evaluate the COA. It is particularly noteworthy that battle staff members did not reduce the amount of time they spent Analyzing the COA for Mission 3 even though they attempted to perform only about one-half of the substeps specified for that MDMP step.

Another interesting difference between Mission 1 planning and Mission 3 planning is the number of battle staff members who worked on a substep. Figure 11 shows:

- the percentage of substeps that were not performed (designated *none*),
- the percentage of substeps that were accomplished by a single battle staff member (designated *1*),
- the percentage of substeps for which two battle staff members contributed (designated *2*), and
- the percentage of substeps for which three or more battle staff members contributed (designated *3 or more*).

It is clear from Figure 11 that battle staff members used a different strategy on Mission 1 than Mission 3, presumably because less time was available for planning Mission 3 than Mission 1. A significantly larger number of substeps were performed by one battle staff member during Mission 1 planning than during Mission 3 planning, χ^2 (1, 101) = 7.2, $p < .01$. In contrast, significantly fewer substeps were performed by two staff members (as a team) during Mission 1 planning than during Mission 3 planning, χ^2 (1, 60) = 8.1, $p < .01$. Although fewer substeps were performed during the planning of Mission 3 (12 fewer), the difference was not quite large enough to reach the .05 level of confidence, χ^2 (1,44) = 3.3, $p > .10$. The two missions do not differ in the number of substeps that were performed by a team of three or more battle staff members, χ^2 (1, 19) = 2.6, $p > .20$.

These findings indicate that the strategy employed to compress mission planning time for Mission 3 consisted of (a) eliminating some substeps (mainly for the MDMP step Evaluate the COA), (b) performing the substeps of other MDMP steps in less time, and (c) performance of more substeps as a two-person team and fewer substeps by single individuals. It was not possible to question battle staff members to determine whether or not the strategy used to compress planning time was a deliberate, conscious strategy. Moreover, no data are available to determine whether the strategy employed is more or less effective than alternate strategies.

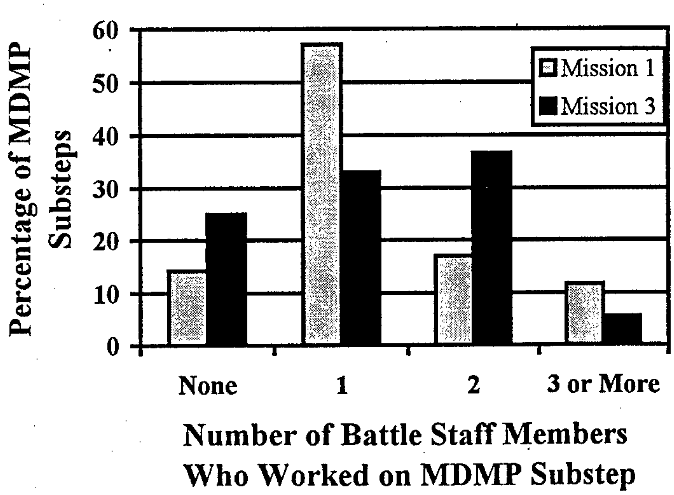

Figure 11. Percentage of all MDMP substeps that were not performed and the percentage of substeps performed by one, two, or three or more battle staff members.

The mission planning observations also provided data on the extent to which individual battle staff members performed the substeps assigned to their battle staff position by the MDMP doctrine (see FM 100-5). Appendix F contains a complete listing of the substeps performed by each battle staff member for each mission. The data for Mission 1 and Mission 3 are summarized in Figure 12 and Figure 13, respectively. In both Figure 12 and Figure 13, a bar with three differently shaded portions is shown for each of seven battle staff positions. The meaning of each of the three portions of the bars is explained below.

- The black portion of a bar represents the number of substeps assigned to the battle staff position (by MDMP doctrine) that were actually performed by the individual assigned to that battle staff position. The legend title for assigned substeps that were performed is *Yes (doctrine)*.
- The white portion of the bar shows the number of substeps that were performed by the battle staff member that was not assigned to the corresponding battle staff position (by the MDMP doctrine). The legend title for these substeps that were performed by not assigned is *Yes (other)*.
- The stippled portion of the bar shows the number of substeps assigned to the battle staff position (by MDMP doctrine) that were not performed by the battle staff member who occupied that position. The legend title for substeps that were assigned but not performed is *No (Doctrine)*.

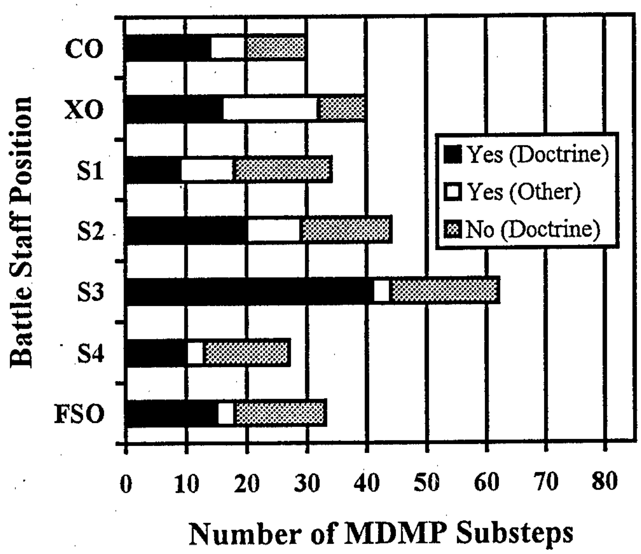

Figure 12. Distribution of MDMP substeps performed and MDMP substeps not performed by battle staff members during the planning of Mission 1.

When interpreting the data shown in Figure 12 and Figure 13, it should be kept in mind that the number of substeps assigned by MDMP doctrine is not the same for all battle staff positions. The MDMP doctrine assigns the largest number of substeps to the S3 (59 substeps) and the S2 (35 substeps). About 25 substeps are assigned to each of the remaining battle staff positions.

A comparison of the distributions shown in Figure 12 and Figure 13 reveals useful insights about the battle staff's strategy for accommodating to the compressed planning time for Mission 3. The most striking change is in the distribution of substeps among the battle staff members. In planning Mission 1, every battle staff member performed or assisted in performing 13 or more substeps (see Figure 12). The largest number of substeps were performed by the S3 (44 substeps), the XO (32 substeps), and the S2 (29 substeps). The substeps performed in planning Mission 3 (see Figure 13) were far less evenly distributed among battle staff members than in planning Mission 1. The CO, S1, S2, S4, and FSO performed fewer substeps in planning Mission 3 than in planning Mission 1. Conversely, both the XO and S3 performed a larger number of steps and a larger percentage of substeps in planning Mission 3 than in planning Mission 1.

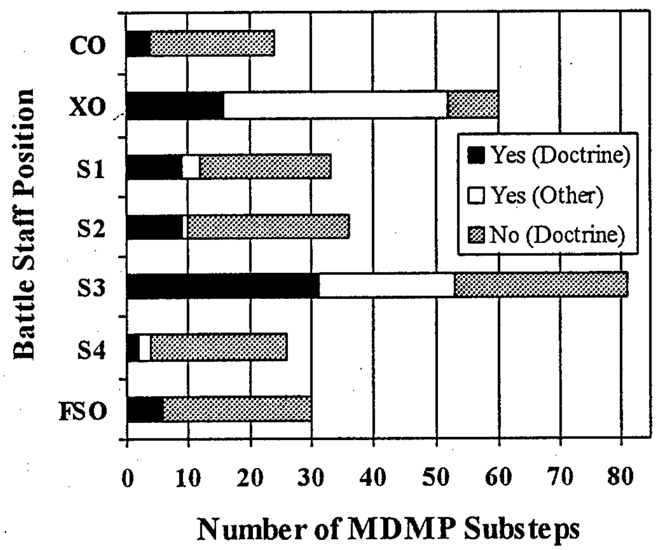

Figure 13. Distribution of MDMP substeps performed and MDMP not performed by battle staff members during the planning of Mission 3.

Together, the XO and S3 performed 43.7% of the 141 substeps that were performed in planning Mission 1 and 74.5% of the 141 substeps that were performed in planning Mission 3. After normalizing the frequencies for the same total number of substeps performed, a χ^2 test shows that the number of substeps performed by the XO and S3 (combined) was significantly smaller for Mission 1 than Mission 3, χ^2 (2, 181) = 4.3, $p < .05$.

Another interesting difference between Mission 1 and Mission 3 is the number of nondoctrinal substeps performed by the battle staff members. In planning Mission 1, the S3 and the S4 performed 3 nondoctrinal steps, the CO performed 6 nondoctrinal steps, the S1 and S2 performed 9 nondoctrinal steps, and the XO performed 16 nondoctrinal steps. In planning Mission 3, the number of nondoctrinal steps performed decreased for every member of the battle staff except for the XO and S3. From Mission 1 to Mission 3, the number of nondoctrinal substeps performed by the XO and S3 increased from 16 to 36 and from 3 to 22, respectively.. Together, the XO and S3 performed a significantly larger number of nondoctrinal tasks during

the planning of Mission 1 (19 substeps) than during the planning of Mission 3 (58 substeps), χ^2 (1, 91) = 17.2, $p < .001$.

Other observations. Items on the data collection forms asked observers to record other events that occurred during mission planning, particularly the types of problems that battle staff members encountered when attempting to perform the MDMP steps. For each MDMP step, observers were asked to record each instance of a variety of specific problems listed on the data collection form (see Appendix C). For the reasons discussed in the next subsection, observers were limited in their ability to detect and report many of the types of problems that were of interest. Even so, a number of useful observations were recorded by the mission planning observers. The following general observations were derived by synthesizing the specific comments that observers recorded during the three mission planning sessions.

- Distribution of OPORD
  - Some inefficiency resulted from the failure to distribute the OPORD to all the staff members who needed it. This problem occurred in distributing the OPORD for Mission 1 and, to a lesser extent, the OPORD for Mission 3.
- Use of Digital Equipment
  - At the outset, all members of the battle staff lacked knowledge about the capabilities of the ASAS and MCS. Without the civilian operators, neither the ASAS nor MCS could have been used. The S2 had difficulty accessing information available in the MCS and ASAS and had difficulty using the ASAS to produce threat overlays. Staff members encountered problems when attempting to export graphics (i.e., overlays) to another digital system.
  - The digital equipment was used very little in the planning of Mission 1. However, all members of the battle staff were using the digital equipment much more extensively and much more effectively by the time they commenced planning Mission 3.
  - When planning Mission 3, the digital equipment was used much more effectively in performing terrain analysis and in wargaming. However, when planning Mission 3 the battle staff still commenced the planning process with an analog map analysis and butcher paper outlines of COAs.
- Workload
  - Many instances were observed in which battle staff member's workload was very heavy. However, no evidence of excessive workload was observed.
- Need for Additional Automation
  - No evidence of a need for additional automation was observed.
- Need for Information Manager
  - There is a need for a staff member who is responsible for entering analog information into the ASAS and MCS.

Limitations of mission planning observations. The mission planning observers did an excellent job observing and recording the MDMP substeps that were accomplished, the battle

staff members who participated in each MDMP substep, and the time spent on each MDMP step. However, they found it difficult to observe how a battle staff member accomplished an MDMP substep or how well the substep was performed. The mission planning observers' difficulties resulted from three factors. First, a large portion of mission planning activities is cognitive and not directly observable. The only way to obtain information about cognitive activities is to question battle staff members frequently about what they are thinking. Unfortunately, frequent queries about cognitive processes tend to be so obtrusive that they modify the planning process in important ways. Second, the large number of battle staff members and their geographical dispersion make it difficult to continuously observe every staff member with a reasonable number of observers. Third, a great deal of experience in mission planning is needed to detect battle staff members' errors and oversights by observing the products of the various MDMP steps. It is difficult to locate individuals with the requisite experience and, if located, to successfully solicit their support for the amount of time needed.

These findings support the conclusion that the use of mission planning observers is not an effective method for detecting specific types of problems encountered during mission planning, particularly the specific errors and oversights made in performing specific MDMP steps and substeps.

Mission Execution

This subsection of the report describes the data that were compiled through observations of the events that occurred in the battalion current operations cell. As discussed earlier, the observation procedures were developed mainly to provide useful data about the flow and management of information during mission execution. It was assumed that such data could be used to draw valid inferences about a variety of important issues, including workload levels, the CO's situation awareness, information management procedures, and the effectiveness with which the digital systems are used.

The observation procedures also were designed to record information about problems that members of the battle staff encountered in performing their jobs during mission execution. It was assumed that the knowledge of such problems could be used to identify the need for improved (a) TTPs, (b) training, and (c) research methodology.

The observation procedures were developed to compile data on the use of each of the digital systems. Unfortunately, only the ASAS, the MCS, and the CSSCS were consistently operational during the period of this study. Although it was not possible to observe the use and utility of the other digital systems, the observations provided useful baseline data on the flow and management of information when the AMDW/S, the FAADEO, and the AFATDS are not available for use during mission execution.

Tabulation of Voice Communication Events

Voice communications were tabulated in a variety of ways in an attempt to identify the tabulation method that best meets the needs of this study. The tabulation method that was decided upon is described briefly below.

A "communication event" was established as the basic unit of analysis. A communication event is defined here as a single one-way transmission of information from one individual to another. For example, a question transmitted from person A to person B was counted as one communication event and the answer transmitted from person B back to person A was counted as a second communication event. Because communication events tended to be uniformly short in duration, the number of communication events per unit time provides a meaningful metric for quantifying the volume of voice communication for battle staff members, individually and collectively.

All the communication events that were recorded in the battalion current operations cell were classified into one of three categories listed below.

- Category A: communication events that involved the CO
- Category B: communication events that involved the XO but not the CO
- Category C: communication events that involved another battle staff member but not the CO or XO

It is important to emphasize that this procedure resulted in the classification of communication events into mutually exclusive and comprehensive categories. A communication event that involved both the CO and XO was classified only into Category A. A communication event that involved the XO and the S3 was classified only into Category B. A communication event that involved any battle staff member other than the CO and XO was classified only into Category C. Because communication events were classified into mutually exclusive categories, the sum of the communication events in the three categories is equal to the total number of communication events that were recorded.

The communication events in each of the three categories were further subdivided with the respect to the individual who originated the communication event and the recipient of the initial transmission. The results of the classification and tabulation of communication events are described in the following subsections.

Volume of Voice Communication Events

The volume of voice communication events is defined here as the number of communication events that occurred during a 15-minute period. Communication event volume can be used to draw useful inferences about the workload of the battle staff members, individually and collectively. It is important to point out that a low volume of voice communication events does not necessarily mean that workload is low. Even if the volume of voice communication events is low, battle staff members could be engaged in a host of other activities that impose a high level of cognitive workload on them.[16] Conversely, it is safe to infer a high level of workload when the volume of voice communication events is high. Because humans are limited in their capability to perform two tasks concurrently, they have little excess attentional capacity when they are engaged in voice communication.

[16] A reduction in the volume of voice communication is sometimes an indication of high workload. When engaged in a task that has higher priority than voice communication, all voice communication may be delayed until the higher priority task has been completed.

The four charts in Figure 14 show the number of communication events per 15-minute interval that occurred in the battalion current operations cell throughout Day 1, Day 2, Day 4, and Day 5 (Day 3 activities did not include any operations). The charts are "stacked" line charts. The number of communication events involving the XO (shaded area) are "stacked" on the number of communication events involving the CO (black area). Similarly, the number of communication events involving other battle staff members (white area) are "stacked" on the communication events involving the XO (shaded area) and those that involved the CO (black area). The upper-most line in each chart shows the total number of communication events per 15-minute interval. For example, the fourth period on Day 1 shows no events for the CO, 7 events for the XO and 10 events for all others; a total of 17 events observed. The communication events shown in Figure 14 are conservative estimates of the number of communication events that actually occurred. Observers undoubtedly missed some communication events during the periods when the volume of communication was very high. However, because of the procedures that were used, there is no chance that observers would have recorded communication events that did not occur.

Figure 14 shows that both the volume and the distribution of communication events varied widely during the day and from one day to another. The intra-day variability in the volume of communication events is due mainly to the type and phase of the mission being conducted. As would be expected, the volume increased abruptly at about the time aircraft and/or UAV were launched, remained high for at least one hour, and decreased abruptly at about the time aircraft completed their egress from the combat areas. The volume of communication events was relatively low during the resupply missions and reconnaissance missions that were conducted during Day 1 and the morning of Day 2. The volume was much higher during the attack missions flown during the afternoon of Day 2 and during both the morning and afternoon of Day 4 and Day 5. The following are examples of observations that can be gleaned from a study of the intra- and inter-day variability in the volume of communication events shown in Figure 14.

- During the morning of Day 1, the XO was involved in a substantial number of communication events, independent of the CO, and the other battle staff members were involved in a substantial number of communication events independent of the CO and XO. The communication load was distributed relatively evenly among the battle staff during the morning of Day 1.
- During the afternoon of Day 2, the XO was involved in a disproportionately large number of communication events independent of the CO.
- During Day 4, there were relatively few communication events in which the CO was not involved. (The XO was not present in the current operations cell during Day 4.)
- During the first part of the mission conducted the morning of Day 5, the communication load was distributed fairly evenly among the CO, the XO, and the other battle staff members. During the last 45 minutes of the mission, however, the CO was involved in nearly every communication event.

- The heavy involvement by the CO continued during the mission conducted on the afternoon of Day 5. During this mission, the CO was involved in more than 62% of all the communication events that occurred.

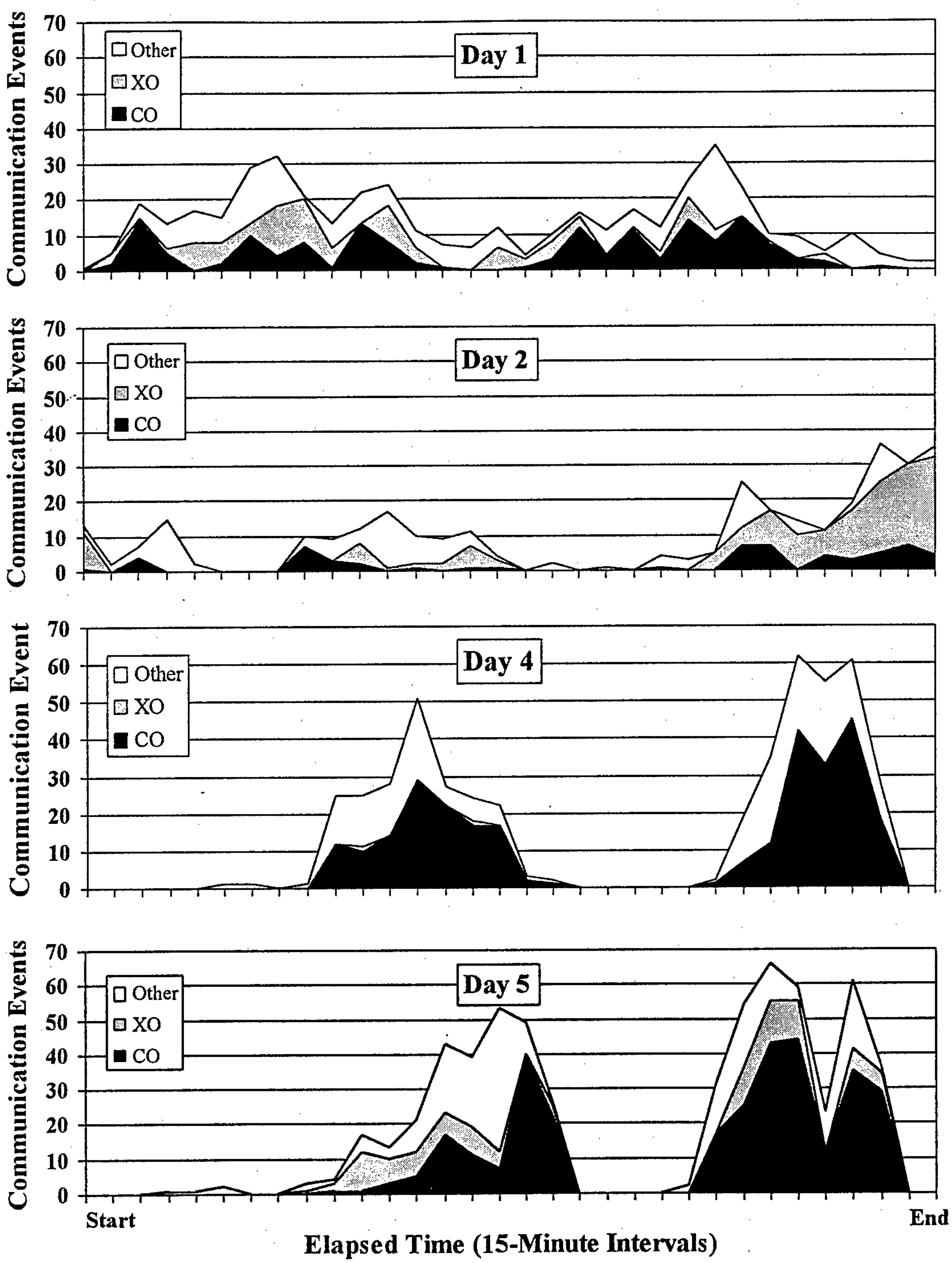

Figure 14. Number of communication events per 15-minute interval that involved the CO, the XO, and all other members of the battle staff on Day 1, Day 2, Day 4, and Day 5.

The total volume of communication events (upper-most line in Figure 14) reached higher levels on the last two days than on the first two days. The total volume of communication events peaked at 35 and 39 on Day 1 and Day 3, respectively. The total volumes of communication events per 15 minute interval peaked at 62 and 66 on Day 4 and Day 5, respectively. The temporal pattern of the total volume of communication events differs widely from one mission to another. For example, note the large difference between the pattern of communication events for the missions conducted during the morning and afternoon of Day 4. During the morning of Day 4, the total volume peaks during a single period at a value (51 events) that is considerably higher than the value for the preceding period (28 events) or following period (27 events). During the afternoon of Day 4, the total volume peaks at a value of 62 events and remains high throughout the two following periods (55 events and 61 events) before declining to a value of 27 events. The mission conducted during the morning of Day 4 was a rehearsal of the mission conducted during the afternoon of Day 4, so the differences in the temporal patterns of total volume are likely due to differences in the information management strategy employed by the battle staff rather than to differences in the mission.[17]

An examination of the communication events for the CO and the XO reveals that their strategy for handling voice communication varied from day to day. On Day 1, it appears that the responsibility for voice communication periodically shifted between the CO and XO. During periods in which the number of communication events was high for the CO, they tended to be low for the XO, and vice versa. No shifting of responsibility is evident in the data for the remaining three days. On Day 2, the volume of communication events was substantially higher for the XO than for the CO during the only high-volume period that occurred that day. However, the volume of communication events was clearly higher for the CO during every high-volume period that occurred during Day 4 and Day 5.

There were a substantial number of time periods during which voice communication imposed a very high level of workload on the individual (CO or XO) who was mainly responsibility for voice communication. During the afternoon of Day 3, for example, there were three 15-minute periods during which the CO was involved in between 33 and 45 communication events. It is safe to conclude that the CO had little time or attentional resources to perform other tasks when, on average, he was involved in between two and three communication events per minute.

The absence of the XO is one reason why the CO's volume of communication events was so high during the mission conducted the afternoon of Day 4. However, the CO's volume of communication events was very high during the mission conducted the afternoon of Day 5 even though the XO was present and was involved in a substantial number of communication events. During one 15-minute period, for example, the CO participated in 43 communication events, and the XO participated in 11 communication events that did not involve the CO. During the next period the numbers of communication events for the CO and XO were 44 and 11, respectively.

[17] The mission conducted the morning of Day 5 was a rehearsal of the mission conducted in the afternoon. So, like Day 4, the differences between the two Day 5 missions may be attributed to differences in the battle staffs' information management strategies rather than to differences in mission type.

The numbers in the "other" category can be correctly interpreted only by taking into account the frequency with which one of the "other" battle staff members communicated with the CO and/or the XO. Data are presented in following sections that show that there were relatively few communication events in which one of the "other" battle staff members communicated with either the CO or the XO. For this reason, it is safe to conclude from Figure 14 that the relatively small volumes of communication events for the "other" category indicate that voice communication did not impose a high level of workload on the "other" member of the battle staff, individually or collectively.

The relationship between the volume of communication events in the "CO" category and the "other" category is a potentially useful indicator of the information management strategy employed by a battle staff. A strong, positive relationship (volumes tend to rise and fall together) indicates that the communication load is distributed between the CO and the other battle staff members. A negligible or a negative relationship indicates a lack of distribution of communication load. Pearson product moment correlation coefficients (Guilford and Fructer, 1978) were computed to quantify the relationship between the volume of communication events in the "CO" category and the "other" category. Correlation coefficients are shown in Table 6 for the communication events that occurred in the morning and in the afternoon of Day 1, Day 2, Day 4, and Day 5.

Table 6

Pearson product moment correlation coefficients between the volume of communication events in the "CO" category and the volume of communication events in the "other" category.

Day	Time of Day	Number of Periods	Pearson *r*	p
Day 1	a.m.	16	.203	> .10
	p.m.	16	.202	> .10
Day 2	a.m.	12	-.356	> .10
	p.m.	14	.322	> .10
Day 4	a.m.	12	.735	< .01
	p.m.	7	.581	> .10
Day 5	a.m.	13	.207	> .10
	p.m.	8	.166	> .10

There was only one time period (morning of Day 4) for which the volume of communication events in the "CO" category is correlated significantly with the volume of communication events in the "other" category, r (10) = .735, $p < .01$. For all other time periods, the correlation coefficients are not large enough to reach the .05 level of confidence. These findings indicate that a constant information management strategy was not used by the battle staff. More important, the findings indicate that the strategy employed during most of the time periods did not promote the distribution of communication load among the battle staff members.

Another potentially useful indication of the information management strategy is the relationship between (a) the total volume of communication events and (b) the percentage of communication events in which the CO was involved. Figure 15 illustrates the nature of this relationship for four 15-minute periods that occurred the afternoon of Day 5.

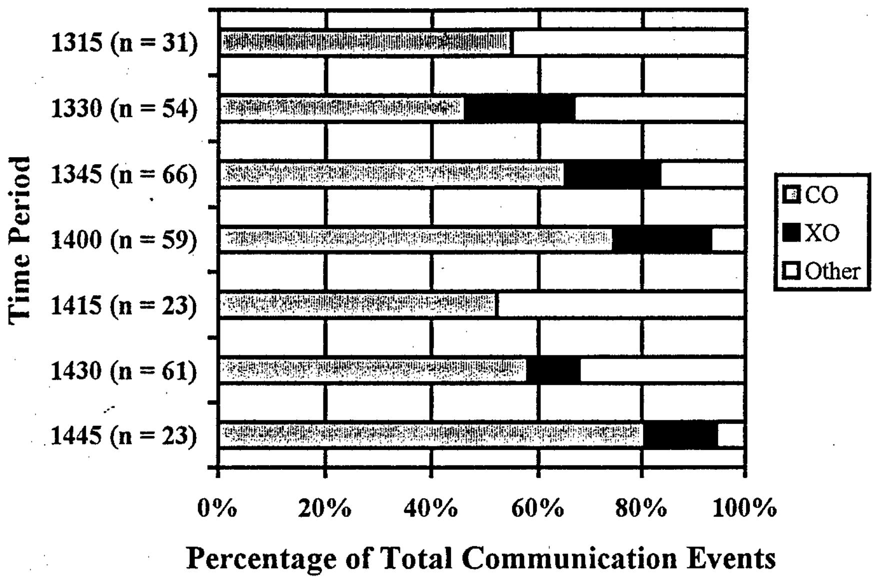

Figure 15. Percentages of total communication events in which the CO, the XO, and other battle staff members were involved. The data are for the mission conducted during the afternoon of Day 5.

The data in Figure 15 show that the percentage of communication events in which other staff members were involved did not tend to increase with increases in the total volume of communication events. During the first period, for example, "other" staff members were involved in 45.2% of the 31 communication events that occurred. During the following three periods, the total volume of events is substantially higher (between 54 and 66) and yet the percentage of events in the "other" category declines first to 33.3%, then to 16.7%, and finally to a low value of 6.8%. The data for the first four periods shown in Figure 15 show an inverse relationship between the volume in the "other" category and the total volume of communication events. However, this trend (inverse relationship) changes suddenly in the fifth period in which the total volume declines to 23 communication events and the percentage in the "other" category increases to 47.8%.

The data presented above suggest that analysis of the volume of voice communication events provides useful information about both the absolute and the relative communication load of the battle staff members. The data also suggest that an analysis of changes in the volume of communication for the different battle staff members provides useful information about changes in the information management strategies that are employed by members of the battle staff. Such changes may reflect a more or less effective distribution of the voice communication load among battle staff members. Such changes also may reflect a more or less effective use of the digital systems for transmitting and receiving information. That is, an increase in the use of the digital

systems to convey information should be accompanied by a corresponding decline in the volume of voice communication events.

Message Content

Each voice communication event was classified in terms of the content of the message that was conveyed. After several iterations, 14 message classes were defined, and each communication event was classified into the most suitable class. In the present case, multiple exchanges about the same topic or event were counted as only one message. For example, a question and the answer to that question were counted as a single message. Similarly, a request for information and the response to the request were counted as a single message. Table 7 shows the percentage of messages that were classified into each of the 14 message classes.

Table 7

Percentage of daily communication events that were classified into each of 14 message classes.

Message Category	**Day 1 (March 2) *n*=351**	**Day 2 (March 3) *n*=288**	**Day 4 (March 5) *n*=383**	**Day 5 (March 6) *n*=487**	**Total *n*=1509**
Orders/Requests to Take Action	8.0%	11.1%	22.7%	25.9%	18.1%
Spot Reports	4.0%	13.2%	25.1%	22.6%	17.1%
Messages About Mission Plan/Status	22.2%	11.5%	10.2%	9.0%	12.9%
Messages About Aircraft Location	8.3%	10.1%	15.9%	15.2%	12.8%
Intelligence Other Than Spot Reports	7.7%	8.0%	4.4%	7.4%	6.8%
Messages About OPORD/FRAGO/WO	12.0%	12.1%	2.1%	1.0%	6.0%
Messages About Downed Aircraft	9.7%	6.6%	0.3%	3.7%	4.8%
BDA Reports	0.9%	3.5%	8.6%	4.1%	4.4%
Questions About Digital Systems	7.7%	4.9%	1.8%	2.3%	3.9%
Messages About CSS	4.8%	0.6%	0.8%	0.4%	2.9%
Requests to Change Display	3.1%	3.5%	1.3%	3.5%	2.8%
Descriptions of Tasks Performed	3.1%	1.4%	1.3%	1.6%	1.9%
Messages About Unit Organization	4.0%	2.4%	1.8%	0.0%	1.9%
Other	4.6%	4.2%	3.7%	3.3%	3.8%

Table 7 shows the percentages of total messages that were classified into each message class. Percentages are shown for each day (Day 1, Day 2, Day 4, and Day 5) and for the total messages pooled across the four days (right-hand column). The number shown at the top of each column (e.g., $n = 351$) is the total number on which the percentages in that column are based. The frequencies for any cell can be determined by multiplying the number at the top of the column by the percentage value in the cell of interest and dividing the product by 100.

The data in Table 7 provide useful information about how and why attentional resources are spent conveying information among battlefield elements. When interpreting these data, it should be kept in mind that a very large percentage of the messages involve the CO or XO. For

this reason, the data in Table 7 are heavily influenced by the information needs of the CO and XO and by their need to convey information (including orders) to other elements. For the most part, the meaning of the data presented in Table 7 is self-evident. Noteworthy findings that may not be immediately apparent to the reader are described briefly below.

Orders/requests to take action. Most of the messages in this class are orders issued by the CO or XO to aircraft pilots or to the UAV operator (e.g., change your position, remain in your present position, attack a target, do not attack yet). A small number of messages in this class were orders or requests from the Brigade to the CO or to the XO. Orders or requests to take action account for a large percentage (18.1%) of all messages that occurred during the 4 days for which missions were conducted. However, the percentage of messages in this class increases dramatically over the 4-day period. The percentage increases from a low of 8.0% on Day 1 to a high of 25.9% on Day 5, a highly significant change, χ^2 (1, 487) = 46.1, $p < .001$. The number of messages in this class is partly a function of the type of missions that were conducted during the day. However, the percentages also reflect changes in the command style of the CO and XO. On Day 4 and Day 5, for example, the CO was far more actively involved in instructing the aircraft about where to fly and what to do than on Day 1 and Day 2.

In future exercises, the number of messages in this class could serve as a useful metric of command style; they also could serve as useful feedback for training on information management and command style.

Spot reports. Spot reports account for only a small percentage (4.0%) of the messages that occurred on Day 1. However, the percentage of spot reports increases significantly (13.2%) on Day 2, χ^2 (1, 487) = 24.0, $p < .001$, and again (to 25.1%) on Day 4, χ^2 (1, 487) = 46.1, $p <$ .001. The decline in percentage from Day 4 to Day 5 is not large enough to reach the .05 level of confidence, χ^2 (1, 487) = .62, $p > .3$. The percentages for Day 4 and Day 5 are most representative of the contribution of spot reports to the volume of communication events during missions that involve both reconnaissance assets (aircraft and UAV) and attack assets.

It is important to note that spot reports were sometimes conveyed directly to the CO and sometimes to the BC. Although the ASAS and MCS operators were expected to enter spot report data into their respective systems, there were few instances in which either the CO or the BC overtly conveyed the spot reports to the digital systems operators. Because the messages were heard on speakers rather than headphones, it can be assumed that the operators were able to hear most of the spot reports. However, there is no way the observers could determine the number of instances in which the digital system operators heard spot reports announced on the speakers.

The inability to track the flow of spot report information to the digital system operators is an important methodological shortfall. The use of speakers eliminates the requirement to convey spot report information in a manner that would be required if head phones and independent radio channels were required. This leads to an underestimate of the volume of communication events that would occur with conventional voice communication systems that are used in both ground-based and airborne TOCs. In future exercises, this problem could be eliminated if all spot report

information was conveyed via radio headphones worn by both battle staff members and observers.

Messages about mission plan/status. This message class includes a very wide variety of questions about the mission plan or the status of the mission. Listed below are examples of questions or announcements that were classified into this message category:

- take-off times, changes in time schedule, and time remaining (on station or until an event is scheduled to occur);
- location of important geographic locations (e.g., FLOT, NAIs, FARPs);
- graphics or coordinates of graphic objects;
- artillery fires planned, ongoing, or completed;
- CO's intent (e.g., intent to bypass troops, intent to engage target);
- capability to attack target or to direct artillery fire;
- mission status (e.g., aircraft are enroute, aircraft are engaging targets, units will be moving shortly); and
- availability of resources (e.g., UAV, artillery, ammunition).

The percentage of messages about mission plan and status is significantly higher for Day 1 (22.2%) than for Day 2, χ^2 (1, 487) = 16.8, $p < .001$, or Day 4, χ^2 (1, 487) = 21.8, $p < .001$, or Day 5, χ^2 (1, 487) = 16.8, $p < .001$. These differences between Day 1 and the following days stem mainly from the many questions and announcements that were needed on Day 1 to resolve battle staff members' uncertainties about (a) the specific missions that were being planned and conducted and (b) the procedures to be used during the execution of missions. The percentages for Day 2, Day 4, and Day 5 do not differ significantly, χ^2 (1, 487) = .33 to 1.4, $p > .50$.

Messages about aircraft location. Messages in this category include both requested and unsolicited reports by pilots or the UAV operators about the location of their aircraft. Most requests for information about aircraft location were made by the CO or by the XO. The percentages of messages about aircraft location do not differ for Day 1 and Day 2, χ^2 (1, 487) = .87, $p > .50$, and do not differ for Day 4 and Day 5, χ^2 (1, 487) = .10, $p > .70$. However, the percentages are significantly higher for Day 4 (15.9%) and Day 5 (15.2%) than for Day 1 (8.3%) and Day 2 (10.1%), χ^2 (1, 487) = 5.1 to 11.8, $p < .05$. Differences in the types of missions flown on different days certainly contributed to differences in the percentages of messages about aircraft location. However, differences in command strategy or style also contributed to the day-to-day differences. Increases in the percentage of messages that were orders or requests to take action (see above discussion) indicate that the CO and XO were more actively involved in controlling the actions of the aircraft on Day 4 and Day 5 than on Day 1 and Day 2. It is reasonable to assume that more active control requires more frequent updates about the current location of the aircraft.

The percentage of messages that conveyed information about aircraft location probably would be considerably smaller if the AMDW/S and/or the FAADEO had been operational and capable of tracking the location of friendly aircraft. In future studies, it will be of interest to determine the extent to which the AMDW/S, FAADEO, or other digital systems reduce the percentage of messages that convey information about the current location of the aircraft.

Questions about digital systems. Messages in this category are either questions or answers about the capability or operation of the digital system. No attempt was made to record the messages between the military equipment operator (ASAS or MCS) and the civilian who assisted in operating the equipment. About 71% of the messages in this class were questions posed by the CO or XO. About 21% of the questions were posed by the BC, and the remaining 7.8% were posed by another battle staff member. Equal numbers of questions were directed at the MCS and ASAS. Questions about the ASAS or the MCS accounted for nearly 90% of all messages in this class. One question was asked about the UAV display, and three questions were asked about the JSTARS system.

As would be expected, the percentages of messages about the capabilities of the digital systems decline significantly from Day 1 (7.7%) to Day 2 (4.9%), χ^2 (1, 487) = 17.6, $p< .001$, and decline significantly from Day 2 to Day 4 (1.8%), χ^2 (1, 487) = 6.7, $p< .01$. The percentages for Day 4 and Day 5 do not differ significantly, χ^2 (1, 487) = .22, $p> .50$. Because most of the questions were posed by the CO and XO, this trend is probably attributable to skill acquisition by the CO and the XO.

The questions posed by members of the battle staff provide useful information about specific deficiencies in battle staff members' knowledge about digital systems. However, the number of such questions asked is not a valid metric of the battle staff member's individual or collective knowledge. A battle staff member's knowledge about a digital system may be so meager that he or she is incapable of asking meaningful questions about its capability or function. Furthermore, a battle staff member may be reluctant to ask a question that reveals his or her lack of knowledge.

Requests to change a display. Most of the messages in this class are requests by the CO or XO to (a) change the system that appeared on the large video-wall display (to/from ASAS to/from MCS), (b) scroll the display to a different location, or (c) zoom the display in or out on a specific feature or area. The data in Table 11 show no trends suggesting that the CO and XO learned to take advantage of their capability to change, scroll, and zoom the ASAS and MCS displays. Conversely, the data provide no evidence that the ASAS and MCS operators learned to change, scroll, or zoom the displays in anticipation of the needs of the CO and XO. Although the percentage of messages in this class was significantly less on Day 4 than for all other days, χ^2 (1, 487) = 3.8 to 4.8, $p< .05$, the reasons for the decline on Day 4 are not known.

The messages in this class suggest the possible need to provide the CO and XO with controls that would enable them to directly change, scroll, and zoom. The number of messages in this class may serve as a sensitive measure of the effectiveness of such devices.

Information Flow/Management

This section describes the results of analyses of the flow of information to and from the CO and the flow of information to and from the XO. The description of the results of these analyses is preceded by introductory comments about the rationale underlying the analyses that

were conducted. These comments should enable the reader to better understand the implications of the data that are presented.

Introductory comments. The ultimate purpose of the equipment, personnel, and procedures employed in a command and control center is to provide the information that the CO must have to establish and maintain an adequate level of situation awareness. By definition, an adequate level of situation awareness requires that the CO have information of the type, quantity, and currency to perform the broad functions listed below (Endsley, 1995a; Endsley, 1995b; Endsley, 1997; Garland and Endsley, 1995; Gilson, Garland, and Koonce, 1994).

- Perceive all available information about battlefield elements, including both friendly and opposing forces.
- Comprehend the meaning of all information about battlefield elements when evaluated in the context of existing topography, mission, and command level.
- Project battlefield elements into the near-term future and correctly interpret the forecast.

Research to assess the design and use of a command and control system, such as the ATCCS, must examine the manner in which the CO acquires the information needed to establish and maintain situation awareness. According to contemporary information theory, there are two basic methods by which a CO acquires information: the *supply-push* method and the *demand-pull* method (Kahan and Worley, 1989; Schmitt et al., 1994). Supply-push means that information is conveyed to the CO (unsolicited) as it becomes available or in accordance with a predetermined procedure or schedule. By contrast, demand-pull means that information is conveyed to the CO only when the CO requests it. Both methods have advantages and disadvantages. The main advantages of the supply-push method are (a) the CO does not need to request the information, and (b) the information can be provided (pushed) to the CO a short time after it becomes available. The main disadvantage of the supply-push method is the danger that the CO will be inundated with more information than any human can process. Given the capability of contemporary battlefield information systems, information overload by the CO is a near certainty if methods are not developed to *screen* the information flowing into the command and control facility.

The obvious advantage of the demand-pull method is that it minimizes the chances that the CO will be inundated with more information than is needed or more information than can be processed in the time available. The disadvantages of the demand-pull method are (a) the CO's workload is increased by the requirement to request information and (b) the system may contain important information that is not requested by the CO. Important information may not be requested because the CO may be unaware of its presence or because the CO misjudges its importance.

In practice, both the supply-push and demand-pull methods are necessary and are used in varying degree in command and control settings. However, excessive use or ineffective use of either method is likely to be problematic. A clear understanding of the methods by which the CO acquires information is a necessary first step in understanding the information management procedures that are employed in a command and control center and the information management

problems that occur. The purpose of the analyses presented below was to gain a better understanding of the information management methods employed by the battle staff.

<u>Information acquisition by the CO and XO</u>. The communication events in which the CO was the recipient were classified with respect to (a) the source of the information, (b) the method by which the information was acquired (push or pull), and (c) the content of the message (information or a recommended action). The communication events were then tabulated to determine, for each of eight sources, the number of communication events in which:

- information was "pulled" (requested) by the CO,
- information was "pushed" (unsolicited) to the CO, and
- an order from brigade or request for action from brigade was "pushed" to the CO.

It is important to remind the reader that this analysis of information acquisition includes only the information that the CO acquired through voice messages. There is no doubt that the CO acquired some information from the displays that appeared on the video wall, but no data are available on the type or amount of information he acquired from displays. However, because the displayed information was so difficult to discriminate from the CO's position, it is safe to conclude that he acquired only a small amount of information from the video wall displays. This conclusion is supported by the fact that the CO rarely left his desk to view either the wall-mounted displays or the desk-mounted displays.

Figure 16 shows the number of communication events in which information was acquired from each of the eight sources. The numbers shown are a consolidation of the communication events that occurred during the 4 days in which missions were conducted. Also shown in Figure 16 are the relative frequencies with which information was pushed from and pulled from each of the eight sources. Clearly, the most striking finding is the very large amount of information that the CO acquired from the aircraft pilots. Of the 322 communication events in which the CO was the recipient, 166 (51.6%) were events in which information or recommendations came from the aircraft pilots. The information was pulled (requested by CO) from the pilots in 62 (37.3%) events and pushed from the pilots in 102 (71.4%) events. As would be expected, an aircraft pilot infrequently (6 events, 1.2% of total) pushed a recommended action to the CO.

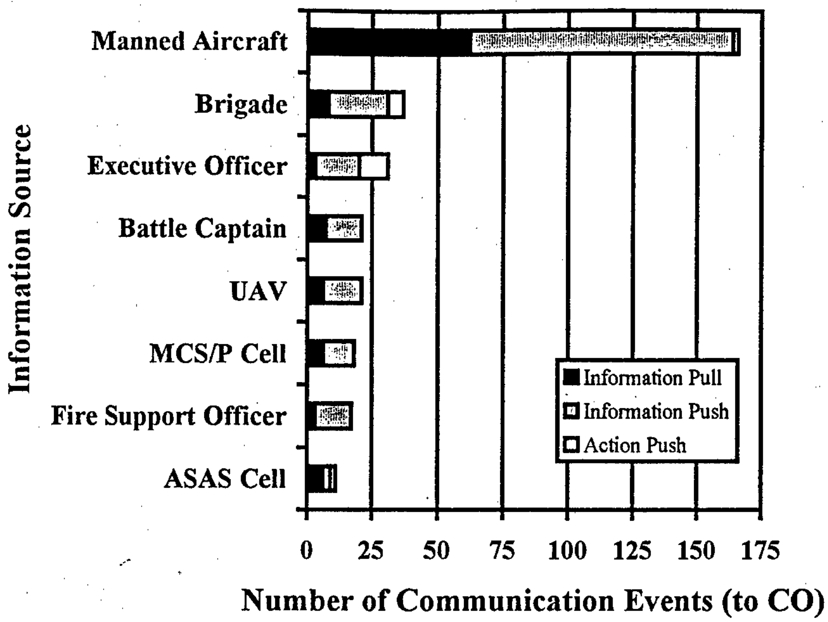

Figure 16. Distribution of communication events in which the CO was the recipient of information or recommended action.

A second important finding is the relatively small amount of information that the CO acquired from the MCS cell, the ASAS cell, the BC, and the XO. During the four days in which missions were conducted, there were only 18 (5.6%) communication events in which the CO acquired information from the MCS cell and only 11 (3.4%) communication events in which he acquired information from the ASAS cell. It might be assumed that the BC and/or XO served as an intermediary in conveying information from the digital system operators (MCS and ASAS) to the CO. This assumption is not supported by the data. There were only 21 (6.5%) communication events in which the CO acquired information from the BC and only 20 (6.2%) communication events in which he acquired information from the XO. Except for that ASAS cell, information was pushed to the CO more often than it was pulled. It is clear from these findings that the CO acquired (directly or indirectly) a relatively small amount of information from the digital systems.

Communication events in which the XO was the recipient were classified and tabulated in the same manner as that described above for the CO. The results are shown in Figure 17. The same ordinate scale was used in Figure 16 and Figure 17 to facilitate comparison of the number and distribution of communication events in which the CO and XO were the recipients.

The XO was the recipient of far fewer communication events (150) than the CO (322), χ^2 (1, 472) = 62.7, $p < .001$. However, the distribution of the XO's information sources is similar to the distribution of the CO's information sources. In particular, aircraft pilots were the source of 48% of the communication events in which the XO was the recipient of information. In addition, the XO acquired a relatively small amount of information from the MCS station (7 communication events), the ASAS station (18 communication events), or from the BC (13 communication events). However, the CO and XO differed in the method by which their information was acquired. Information pull accounts for 66.8% of the communication events in which the XO was the recipient but only 31.4% of the information events in which the CO was the recipient. In short, the XO acquired most of his information by requesting it (information pull) while the CO acquired most of his information through unsolicited messages from various sources (information push).

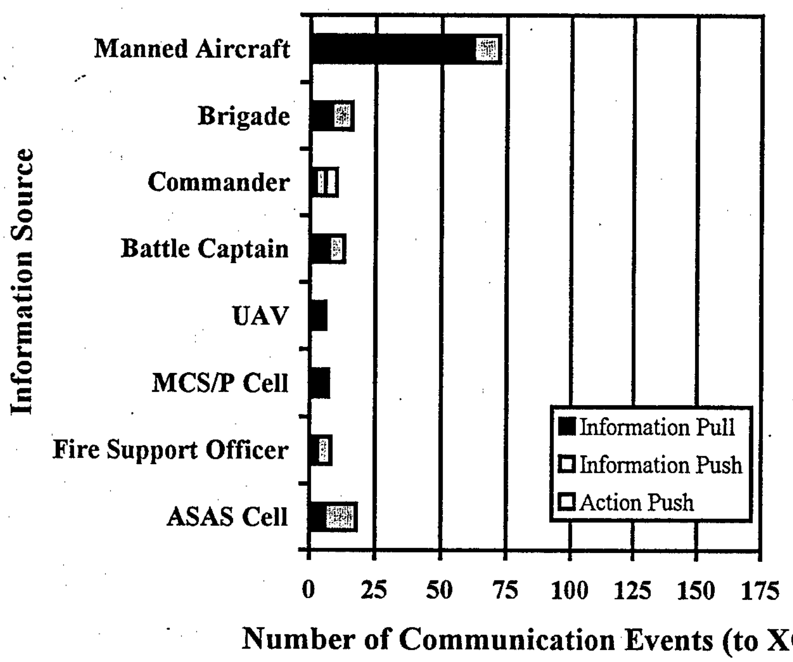

Figure 17. Distribution of communication events in which the XO was the recipient of information or recommended action.

Information dissemination by the CO and XO. The communication events originated by the CO were classified in terms of the recipient of the communication. The communication events for each recipient were further classified into three categories: information pull, information push, and action push. Information pull means that the CO conveyed information in response to the recipient's request for information. Information push means that the CO conveyed information that was not solicited by the recipient. Action push means that the CO conveyed an order or a recommended action to the recipient.

Figure 18 shows the distribution of communication events in which the CO disseminated information. Aircraft pilots were the recipients of 142 (56.1%) of the 253 communication events for which the CO disseminated information or an order. The CO infrequently (4 communication events) disseminated information to a pilot in response to the pilot's request for information (information pull). Similarly, unsolicited dissemination of information by the CO (information push) accounts for only 26.8% of the communication events in which a pilot was the recipient. In contrast, the dissemination of orders by the CO (action push) accounts for 70.4% of the communication events in which a pilot was the recipient. These data provide further evidence of the CO's active involvement in directing the action of the aircraft during the conduct of the missions.

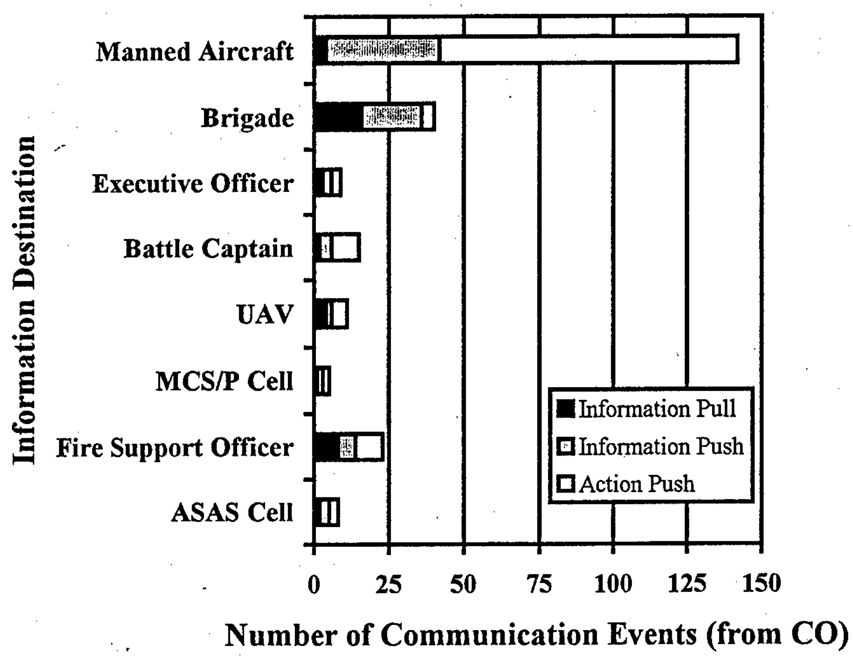

Figure 18. Distribution of communication events in which the CO disseminated information to another battle staff member or to another battlefield element.

The data in Figure 18 provide no evidence that the CO routinely disseminated information through intermediary staff members. There were instances in which the CO asked the XO or the BC to communicate information to brigade, aircraft pilots, and the UAV operator. However, this was not a routine method for disseminating information. The XO was the recipient of only 3.6% of the communication events for which the CO disseminated information; the BC was the recipient of only 5.9% of the communication events in which the CO disseminated information.

During the 4 days in which missions were conducted, there were only 107 communication events in which the XO was the originator. These communication events were classified in the same manner as for the communication events in which the CO was the originator. The results are shown in Figure 19. To facilitate comparison, the same ordinate scale was used for Figure 18 and Figure 19. As was true for the CO, most of the information

disseminated by the XO was unsolicited by the recipient. The dissemination of unsolicited information by the XO (information push) accounts for 53.3% of the communication events; disseminating information in response to a request (information pull) accounts for only 15.9% of the communication events. The most frequent recipients of information from the XO were the CO (33.6%), the manned aircraft (18.7%), the ASAS cell (16.8%), and the BC (15.9%). No other recipient accounts for more than 7.5% of the communication events.

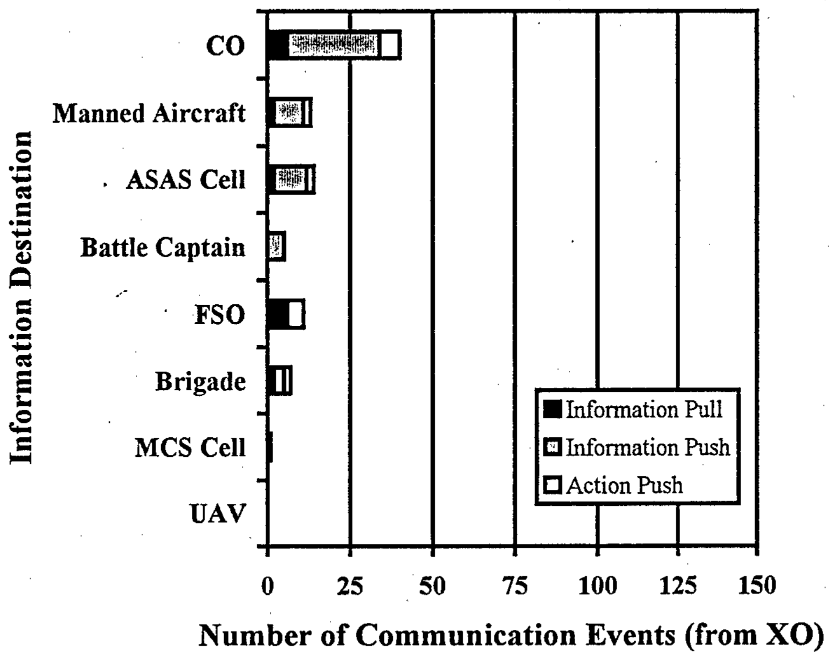

Figure 19. Distribution of communication events in which the XO disseminated information to another battle staff member or to another battlefield element.

<u>Information received by and relayed by the BC</u>. A potential role of a BC is to reduce the CO's voice communication workload by receiving messages from battlefield elements and relaying relevant information to the CO. The data were tabulated to determine the number of communication events in which the BC was the recipient of information that was subsequently relayed to either the CO or XO. There were 58 communication events in which the BC was the recipient of information sent from brigade. In only 8 events (13.7%) did the BC convey the information received from brigade to the CO or to the XO. Of the 104 communication events in which the BC was the recipient of information sent from an aircraft, there was only one communication event in which the BC relayed the information to the CO or to the XO.

Much of the information received from brigade and from the aircraft was sufficiently important to warrant relay to the CO or XO, so the failure to do so does not reflect prudent screening by the BC. It is possible that the BC assumed that the CO or XO heard the messages because they were transmitted to a speaker located on the BC's desk. Regardless of the reasons, however, these data indicate that suitable TTPs were not established to guide the BC in managing the information conveyed to him from other battlefield elements.

Post-Exercise Training Effectiveness Survey

This subsection describes battle staff members' responses to the Training Effectiveness Questionnaire (see Appendix E) that every battle staff member completed following the last mission execution exercise. The questionnaire has 5 items for each of six topical areas (scales) entitled learning, exercise conduct, future application, digital system utility, instructional feedback, and enjoyment. The items developed for each scale are shown on the last page of Appendix E. Even at first glance, however, it was clear that the researchers' construction of dimensions underlying the items on this survey instrument did not provide a representative model of the dimensions along which the participants responded. Items that should have exhibited correlation as a result of membership in a common scale showed essentially unrelated results. In short, the underlying structure of the survey proved to be invalid. There were, however, consistent patterns of responding evident in the data.

Because of the manner in which battle staff members responded to the items, the items have been grouped in a different way in the following description of the findings. In the following subsection, the items were grouped into four sets. The first set includes items that reflect battle staff members' opinions about the training benefits of the ATCCS exercise. The second and third sets include items that reflect battle staff members' opinions about the conduct of the exercises and the utility of the digital systems, respectively. The fourth set includes items that reflect the degree to which battle staff members enjoyed participating in the exercises. This organization of items better fit the dimensions along which participants appear to have interpreted the items.

Training Benefits

The data in Table 8 show battle staff members' agreement with 12 statements about the training benefits of the ATCCS exercise. The numbers in the cells adjacent to each statement are the percentages of battle staff members who selected the corresponding rating-scale alternative. These data leave no doubt that, as a group, battle staff members believed that they realized training benefits from participating in the ATCCS exercise. There is a very high level of agreement with each of the first 11 statements listed in Table 8. For each of these statements, no fewer than 64% of the battle staff members agreed (mildly or strongly) and no more than 18% disagreed (strongly or mildly) with the statement. Because the training was not aimed specifically at leadership skills, it is not surprising that only 36% of the battle staff members agreed mildly or strongly with the statement "This training helped my leadership skills."

Table 8

Battle staff members' opinions about the training benefits of the ATCCS exercise.

Survey Statement	Rating-Scale Alternatives: Strongly Disagree	Mildly Disagree	Neutral	Mildly Agree	Strongly Agree
I know more now than I did before the exercise	--	--	--	45%	55%
This was a good learning experience for me	--	9%	--	82%	9%
I acquired new skills from the ATCCS exercise	--	9%	--	91%	--
The ATCCS exercise was a useful learning experience	--	9%	--	82%	9%
I feel I gained substantial benefit from the ATTCS exercise	9%	--	9%	55%	27%
I intend to use what I learned during the exercise in future assignments	--	9%	9%	64%	18%
I believe that this experience will help me perform better as a staff officer	--	9%	18%	45%	27%
I have a better level of ability as a staff officer because of this exercise	--	9%	27%	64%	--
I learned a great deal during the ATCCS exercise	--	9%	27%	55%	9%
I intend to apply what I learned in field assignments	--	--	36%	64%	--
This training will have a positive effect on my future performance	9%	9%	18%	64%	--
This training helped improve my leadership skills	9%	18%	36%	27%	9%

Conduct of Exercise

Table 9 shows battle staff members' agreement with each of nine statements about the manner in which the exercises were conducted. Between 63% and 91% of the responses indicated that they agreed mildly or strongly with the first three statements listed in Table 9. So, most battle staff members shared the opinion that (a) use of the ATCCS suite promoted practice of relevant skills, (b) the AAR process was a useful learning tool, and (c) the feedback received during the exercises was important. However, no more than 45% and as few as 9% of the battle staff members agreed mildly or strongly with any of the remaining statements listed in Table 9. There was no consistency in battle staff members' agreement with the statements that (a) the observers provided beneficial instruction, (b) the scenarios simulated battlefield conditions, (c) the ATCCS exercise lasted the right amount of time, or (d) the observers provided good analyses of the battle staff performance. For all four items, the percentage who agreed is about the same as the percentage who disagreed.

There is more consistency in battle staff members' responses to the last two statements listed in Table 9. About 55% of the battle staff members disagreed mildly with the statement "The ATCCS environment was well designed." Battle staff members' opinions about the ATCCS design probably would have been more favorable if all the digital systems had been functioning properly during all of the exercises. Inadequate training on the function and operation of the digital systems is the most likely reason why 72% of the battle staff members disagreed strongly or mildly with the statement "I was well prepared for this training exercise."

Table 9

Battle staff members' opinions about the conduct of the ATCCS exercise.

Survey Statement	Rating-Scale Alternatives: Strongly Disagree	Mildly Disagree	Neutral	Mildly Agree	Strongly Agree
Skills required in the ATCCS exercise are important during field exercises	--	9%	--	55%	39%
The AAR process was a useful learning tool	--	9%	18%	45%	27%
The feedback I received during this exercise was very important	--	18%	18%	55%	9%
Observers/controllers provided beneficial instruction	18%	18%	18%	36%	9%
The ATCCS scenarios well simulated actual battlefield engagements	18%	18%	27%	36%	--
The ATCCS lasted the right amount of time to be useful	18%	27%	18%	27%	9%
The observers provided good analyses of the battalion staff performance	--	27%	36%	27%	9%
The ATCCS environment was well designed	--	55%	18%	27%	--
I was well prepared for this training exercise	27%	45%	18%	--	9%

Digital System Utility

Battle staff members rated their agreement with five statements about digital system utility. Most battle staff members agreed mildly or strongly to the abstract statements "The digital TOC enhances battalion staff capabilities" (73% agreed) and "The ATCCS suite provides significant improvement in information exchange" (55% agreed). However, the majority of battle staff members disagreed strongly or mildly with the more specific statements "Mission planning is faster in the digitized TOC (82% disagreed), "The exchange of information through digitized communications was easy" (73% disagreed), and "Planning and executing missions is easier in a digitized TOC" (55% disagreed). The lack of training on the digital systems probably was the main reason why battle staff members disagreed with statements that the digital systems saved time and that the digital systems made it easier to exchange information and to plan and execute missions.

Enjoyment

Battle staff members rated their agreement with four statements about the degree to which they enjoyed their participation in the ATCCS exercise. It was assumed that battle staff members would disagree with these statements if they judged that participation was excessively stressful, boring, or tiring. Listed below are the four statements in this set and the percentage of battle staff members who disagreed or agreed with each statement.

- The ATCCS exercise was interesting and enjoyable (18% disagreed and 82% agreed).
- I would like to participate in other similar exercises (18% disagreed and 64% agreed).
- This exercise exceeded my expectations (27% disagreed and 45% agreed).
- I enjoyed myself during this exercise (18% disagreed and 36% agreed).

The battle staff members' responses to these items provide no evidence that the ATCCS exercise was so unpleasant that they would be unsuitable for further research or for battle staff training.

Synopsis of Reported Problems

Throughout this research, battle staff members were asked to describe problems they observed or experienced during mission planning or mission execution. Battle staff members' descriptions of problems come from three sources. One source is battle staff members' responses to the open-end questionnaire items that invited them to express their views about a variety of topics and issues. A second source is the observers' notes. During both mission planning and mission execution, observers recorded battle staff members' comments about the problems they observed or experienced. The third source is interviews with the XO, S1, S3 and S4, which were conducted the week after the study had been completed (March 9-13, 1998). A large number and wide variety of problems are revealed in these three sources. In addition, the problems were expressed in a variety of ways. In some instances, battle staff members described solutions rather than problems. In such instances it was necessary to infer problems from the solution that was offered. In other instances, battle staff members described problems that were, in fact, symptoms of a more fundamental problem.

The problem descriptions presented in this subsection are a synopsis of the problems identified by the battle staff members. The problems are subdivided into two groups. The first group includes problems that bear on the research methods and facilities that were used. The second group includes a variety of problems that bear on the design of the ATCCS equipment. All of the equipment design problems can be related to problems that battle staff members encountered in performing tasks during mission planning or mission execution. Although improved training or improved procedures may be a partial solution for some of the problems, battle staff members' comments indicate clearly that improvements in the design of system hardware or software were considered to be the preferred solution.

Research Methods and Facilities

Training. A problem identified by virtually all battle staff members is the lack of sufficient prior training. Battle staff members stated they should have had more training on both the capability and operation of the digital systems. They also stated that more training was needed to enable them to work together effectively. Battle staff members expressed the view that much more could have been learned about the use and utility of digital systems if they had received at least one more week of training exercises in the ATCCS.

Battle staff members experienced problems in performing terrain line-of-sight (LOS) analyses with the digital systems and problems in interpreting the results of the analyses. Battle staff members indicated that these problems would not have occurred if they had adequate prior training on (a) the use of the digital systems to perform LOS analyses and (b) the precision with which LOS analyses can be performed with the digital systems. Battle staff members also stated

that they should have had more training on the use of the digital systems to evaluate ingress routes and egress routes quickly and effectively during mission execution.

Battle staff members acknowledged the value of having civilian operators available to train the military ASAS operators and MCS operators. However, the observers noted that the civilian operators encountered difficulty performing some tasks because of their lack of recent practice in operating the system.

Procedures. The root cause of several of the problems described by battle staff members was a lack of operating procedures or SOPs. One set of problems stems from inadequate procedures for determining the information that should be displayed on the large format wall-mounted display and, to a lessor extent, the desk-mounted displays (ASAS and MCS). Battle staff members stated that procedures must be developed to avoid the following problems.

- The CO and XO were unable to see the map display and graphics because it was obscured by a pull-down menu or by another window (e.g., message window).
- The CO and XO often found it necessary to request operators to change the system that was displayed on the main wall-mounted display.
- The CO and XO often found it necessary to direct the digital system operators to scroll a map display to a different location and to zoom in or out on a specific geographical location of a feature. The CO, XO, and digital system operators exhibited considerable uncertainty about the best display magnification (zoom level) to accomplish different tasks or different mission phases.

A second set of problems stems from the lack of effective information management procedures. In particular, no clear procedures were established for processing either in-coming or out-going information. As stated earlier, the BC was the recipient of a substantial amount of information (e.g., spot reports from aircrews and the UAV operator) that was not overtly relayed to the CO or XO. In addition, no consistent procedures were followed in conveying information to external elements or in receiving information from external elements. At different times, information was conveyed to external elements and received from external elements (brigade, the aircrews, and the UAV operator) by the CO, the XO, the BC, and the S3. Finally, no procedures were established that specified the responsibilities for monitoring the digital system displays or the UAV display. Most importantly, no procedures were established that specified the responsibilities of the digital system operators (ASAS and MCS) for monitoring their displays, identifying information needed by the CO (screening information), and conveying (pushing) the information to the CO.

A third set of problems stems from the lack of an effective graphics management procedure. Because of problems they experienced, battle staff members stated that a procedure is needed for (a) identifying at which command level the graphics were created (brigade, battalion, or company), (b) deconflicting graphics created at different command levels, and (c) processing changes in graphics. Battle staff members acknowledged that it may not be possible to develop effective graphics management procedures without changes in the digital-system hardware, software, or both.

Finally, problems experienced by battle staff members led them to recommend the establishment of the specific procedures listed below:

- procedures to ensure that all information from prior missions has been removed from the ASAS and MCS,
- procedures to ensure that all echelons employ a common file-naming method and a common date-time labeling method, and
- procedures to ensure that all files transferred among systems or echelons are accompanied by a free text message that describes the contents of the file.

Planning time. Battle staff members stated that the amount of time available between the receipt of an OPORD or FRAGO and the commencement of mission execution was inadequate for thorough mission planning. The S3 believed strongly that more planning time should have been made available until members of the battle staff learned more about the use of the digital systems for performing planning tasks and until members of the battle staff became accustomed to working together. In one instance, the CO stated that an unrealistically small amount of time was made available between the receipt of a FRAGO and the time at which he was expected to launch his aircraft. This is a subject area in which operational requirements and instructional technique conflict. Current Army policy appears to direct substantial reduction in the timeline of the mission planning cycle from division through company level. An implied assumption of this policy is a significant increase in the rate at which mission planning functions can be completed as a result of computer based tool sets like ATCCS. The tools, however, are unlikely to provide enhancements to planning unless the users are proficient in their employment. Proficiency implies training which requires time. While prospective battle staff personnel are engaged in the process of acquiring this proficiency it may be necessary to plan for greatly extended mission planning cycles and the opportunity for repetition of some tasks in order to facilitate skill acquisition, performance assessment, diagnosis and performance feedback.

Facilities and equipment. Battle staff members identified three shortfalls in the ATCCS facility and equipment that they judged to be especially important. First, the space provided for mission planning was judged to be far too small to accommodate the mission planning equipment and personnel. This problem was solved on the first day of the study by moving the planning cell to a larger room. Second, the battle staff members expressed the view that the voice communication equipment was so unrealistic that it fostered maladaptive communication procedures. Battle staff members stated that (a) the voice communication equipment provided was not an acceptable simulation of the radio systems they use, and (b) some battle staff members had no voice communication equipment of their own. Finally, battle staff members stated that important equipment was not available in the ATCCS facility or was not operational during all or part of the study. Some battle staff members expressed the view that the lack of an Aviation Mission Planning System (AMPS) contributed to the use of some unrealistic procedures during both mission planning and mission execution. Battle staff members also expressed the view that the procedures they used during both mission planning and mission execution would have been different if the AMDW/S, FAADEO, and AFATDS had been operational and manned by a trained operator.

Scenario design. Battle staff members identified attributes of the scenario design that were sufficiently unrealistic to be considered problematic. One attribute was the volume of intelligence information (other than spot reports) that was conveyed to the ATCCS prior to and during mission execution. Battle staff members stated that the low volume of intelligence information resulted in a workload level that was unrealistically low for some members of the battle staff. A second attribute that battle staff members considered highly unrealistic was that CSS functions were not required or were too easy to perform during both mission planning and mission execution. As a consequence, the workload level was unrealistically low for the S1 and S4.

Equipment/System Design

System displays. Battle staff members experienced a variety of problems in extracting information from the system displays. Although some problems stem from a lack of training, most problems are related to the design of the display or the design of displayed information. There were many instances in which battle staff members were unable to discriminate the information portrayed on the large wall-mounted display. These problems are not simply the result of viewing the wall-mounted display from an excessive distance. The BC, who sat only a few feet from the display, complained that he experienced difficulty reading messages and could not discriminate any map information from his position. Although research will be required to determine how best to improve the wall-mounted display, it is clear that significant improvements cannot be achieved by simply increasing its size or decreasing viewing distance. The necessary improvements probably will require increasing brightness, brightness contrast, color contrast, and the number of addressable lines.

Other problems are applicable to both the wall-mounted and desk-mounted displays. Problems identified that are common to two or more displays are listed below.

- The linear symbols (including graphics) depicted on the displays often were so large that they obscure too much map detail. This problem is particularly severe when small-scale maps were displayed.
- There is inadequate brightness and/or color contrast to enable users to easily discriminate graphics that overlay map displays.
- For some types of map displays, it is difficult to discriminate grid lines. Factors that may contribute to this problem include narrow line width, low brightness, and low brightness contrast.
- Some point symbols and alphanumeric characters are difficult to discriminate because an insufficient number of lines are used to portray them.

Tracking friendly aircraft. Both the CO and XO acknowledged that it was very difficult to track the location of friendly aircraft and to determine the location of downed aircraft. Despite the use of numerous control measures, a large amount of voice communication was required to remain reasonably knowledgeable about the current location of the aircraft. The analysis of communication events, discussed earlier, supports the CO's and XO's observations about the difficulty of tracking friendly aircraft.

Because the AMDW/S was either not operational or unmanned during this study, no attempt was made to use the AMDW/S to track the location of friendly aircraft. Although this study provided little information about the use and utility of the friendly aircraft, the XO made the observation that the capability to attach identification "tags" to the friendly aircraft symbols would increase the system's utility for tracking the location of friendly aircraft.

Maintaining awareness of threat forces. Maintaining an awareness of the current location of threat vehicles is a problem that was experienced by the CO, the XO, and probably other battle staff members as well. Three related problems are acknowledged explicitly or are implied by suggestions about system design improvements. The overriding problem is that it is very difficult to process the ongoing flow of spot reports and to integrate this information with the intelligence information available at the outset of the mission. This problem becomes even more severe when aircrews and the UAV operator commence sending BDA reports to the ATTCS.

Although the CO and XO acknowledged that improved training and procedures would help remediate this problem, they indicated that increased automation is also required. During an interview, the XO recommended the design improvements listed below.

- Develop a capability to automatically update the ASAS and MCS when threats are observed by the aircrews or by the UAV operator, including spot reports transmitted by the Automatic Target Handover System (ATHS).
- Develop a capability to facilitate the discrimination of active and destroyed threats. For instance, it was suggested that a capability be developed to change (manually or automatically) the color of a threat symbol when a report is received that the threat has been destroyed.
- Develop a capability to facilitate the discrimination of (a) multiple reports of the same threat and (b) reports of multiple threats. It was recommended that a computer-based decision aid be developed that predicts whether a threat vehicle could have traveled the distance between two spot report locations in the time that has transpired between the first and second spot report.
- Develop a capability that enables users to easily determine the age of intelligence information, especially information about threat type and location. It was recommended that computer software be developed to automatically change the appearance of threat symbols or to remove them from the display when intelligence information exceeds a prescribed age.

Tailoring type and format of displayed information. During an interview with the XO, he stated that display clutter is excessive when all overlay information is portrayed at the same time. He suggested that the best solution to this problem would be to develop a capability to select and display any one or more of a predefined set of overlay formats. The XO expressed the view that a group of experts could probably define a small set of overlay formats that, together, would meet users' needs for the full ranges of missions, mission phases, and contingency situations.

The CO stated that regimental icons do not meet the needs of company commanders. He expressed the view that the systems should be designed such that, on request, the regimental icons are deaggregated and symbols are portrayed that depict the locations of the companies that comprise the regiment.

Interoperability of systems. Battle staff members described a host of problems that are the direct or indirect result of inadequate interoperability of the ASAS and MCS. As was discussed earlier, problems were encountered in transferring graphic information between the ASAS and MCS. The lack of system interoperability contributed to these problems (along with inadequate training and procedures).

The equipment operators shared the view that all digital systems should employ the same topographic map databases and the same map scales. However, they were not questioned systematically about the specific problems that were caused by the lack of commonality in map databases and scales.

It can be expected that the ASAS and MCS will both be accessed routinely by some battle staff members. It would be beneficial if the two systems employed the same scheme for encoding information that appears on both systems. No attempt was made to assess the degree of commonality in the two systems' encoding schemes. However, a few instances were observed in which the CO or XO was confused by differences in the color-coding schemes employed on the two systems.

Map detail. The need for improved training and procedures for changing the display magnification (zooming in and out) was discussed earlier. However, battle staff members suggested that system design changes are needed to provide the level of map detail that is sometimes needed. When the map database remains the same, zooming in decreases the viewing area and increases the size of map features but does not increase the number or type of map features that are portrayed. At present, users can gain access to more map detail only by changing to a database compiled from a larger scale map. This condition is attributable to the use of raster scanned map images in MCS and ASAS. Battle staff members recommended that systems be designed such that access to additional map detail can be gained by zooming in on an area of interest.

Related problems identified by battle staff members are (a) the lack of large-scale (e.g., 1:50,000-scale) databases for some areas, and (b) the excessive amount of time and effort that are required to change from a small-scale to a large-scale database. The S2 suggested that dual systems should be provided in which a large-scale database is portrayed on one system and a small-scale database is portrayed on the other. Most battle staff members suggest that more large-scale databases should be developed for use in both training and operational settings.

Planning aids. Problems experienced during planning led battle staff members to recommend system design improvements. The CO, XO, and S3 expressed dissatisfaction with MCS software. First, they stated that the OPORD format is out of date. Second, they experienced problems in using the MCS to create an execution matrix. Third, they were unable to enter free test messages at desired locations in the execution matrix.

The CO, XO, and S3 indicated that a better digital briefing capability is needed and that this capability should include a light pen type input device ("John Madden Pen") that enables the briefer to make free-hand annotations on digital displays.

Wargaming. Battle staff members indicated that the digital systems do not provide a useful wargaming capability because of the excessive amount of time required to enter the requisite data. Although no specific design solutions were recommended, battle staff members indicated that designers should give more thought to designing the systems to support wargaming. Battle staff members made the general recommendation that more automated wargaming and mission rehearsal tools be developed for use in the ATCCS.

CSSCS design improvements. The S1 and S4 identified a host of problems that, in their view, stem from CSSCS design shortfalls. Listed below are the design changes that were recommended by the S1 and S4 during the post-exercise interview.

- The present CSSCS does not permit users to track elements smaller than a company. The system should be designed in a manner that enables users to create a unit with any composition of aircraft and to predict accurately the fuel and ammunition consumption of that element.
- At present, it is necessary to manually enter data that have already been entered in the system at a different echelon. The system should be designed such that data entered at one location is transferred automatically to other systems in the net.
- Interconnectivity among systems should enable other system displays to be portrayed on the CSSCS display.
- At present, the battalion CSSCS is updated only after a resupply vehicle has returned to the battalion and the vehicle operator calls the S4 on the radio. Until this happens, the CSSCS shows a supply shortage. The CSSCS should be designed to provide more timely information on the status of resupply activities.
- The present system provides information about basis-of-issue rather than information about the supplies that can be drawn. The system should provide information about supplies that, in fact, are available and should provide timely information about shortages.
- The system is not designed to enable users to report or track casualties effectively. The system should be designed to enable the user to track individuals who were injured or killed. Specifically, the system should enable the user to track the location, treatment, and condition of every casualty.
- The CSSCS should be designed to provide more current information about each aircraft's fuel and ammunition load.

Discussion and Conclusions

Tactics, Techniques, and Procedures

The requirements that served as the impetus for this study included the development of baseline TTPs for utilizing C^4I equipment to (a) perform the MDMP steps and (b) monitor the

execution of the DST. Necessary constraints on the design of this study made it unsuitable for identifying near-optimal TTPs. The lack of comprehensive prior training on the functions and operations of the digital systems is among the most important of these constraints. Because of the small amount of training received before the study commenced, the experience that battle staff members gained during the study was barely adequate for them to acquire rudimentary skills in using the digital systems. This problem was compounded by the schedule that was established. The time required to plan and execute the scheduled missions left no time for battle staff members to develop and assess alternate TTPs for utilizing the digital C^4I systems during mission planning or mission execution.

An equally important constraint is the limited number of digital systems that were operational during the study. It cannot be assumed that TTPs established with only three digital systems operational (ASAS, MCS, and CSSCS) would be suitable for use with a fully operational suite of digital systems. The data compiled during the study left no doubt that the procedures that battle staff members employed during mission execution were influenced by the lack of information from the three systems that were not operational (AFATDS, AMDW/S, and FAADEO). It seems certain that quite different procedures would have evolved if the AFATDS, AMDW/S, and FAADEO had been operational and had been manned by skilled operators.

Despite the constraints described above, this study yielded useful information about (a) problems that can be solved, at least in part, by developing TTPs and (b) the general types of TTPs that are needed to solve the problems. Insights gained about the need for mission planning TTPs and mission execution TTPs are discussed below.

Mission Planning TTPs

Two related problems encountered during mission planning point to the need for TTPs that would govern battle staff members' mission planning activities. One problem is inadequate planning time, and the other is the unequal distribution of planning tasks among members of the battle staff. The problems are related, because the planning time inadequacy was due in large part to the unequal distribution of workload among members of the battle staff. In short, the findings of this study support the conclusion that there is a need to develop TTPs that promote a more equal distribution of the MDMP substeps among battle staff members. The TTPs must specify the distribution of work among battle staff members for normal conditions and for conditions in which the planning process must be compressed in time.

Because the amount of planning time can vary over a wide range, the TTPs that govern planning activities under a compressed time schedule should specify methods for tailoring planning activities to the time that is available. In addition, the TTPs should specify (a) the degree to which MDMP substeps can be performed concurrently and (b) the battle staff member who is responsible for determining when work on an MDMP step/substep must be terminated.

As was stated earlier, the number of substeps assigned by MDMP doctrine dictates an unequal distribution of workload among battle staff members. For this reason, it is doubtful that suitable TTPs can be developed without corresponding changes in the MDMP doctrine. It should also be acknowledged that a more even distribution of planning activities may not be

possible without increasing the amount of cross training of battle staff members or increasing the size of the planning staff.

In addition to TTPs that will promote a more equal distribution of workload among the planning staff, TTPs are needed that specify the manner in which each digital system should be used in the accomplishment of each MDMP step. The TTPs must take into account both the overlapping capabilities and the unique capabilities of the different digital systems. The TTPs also must take into account the need to convey information from one system to another and the interactivity (or lack of interactivity) among the digital systems.

There are no reasons to doubt that inadequate training on the digital systems contributed to many of the mission planning problems that were observed during this study. However, it seems highly unlikely that such problems can be solved through additional training on the capabilities and operation of each digital system. For instance, battle staff members can be trained to perform intervisibility analyses on the AMPS, the ASAS, and the MCS, but TTPs are required to specify the circumstances in which each system should be used and by whom it should be used. Similarly, battle staff members can be trained on the interactivity among systems, but TTPs are required to specify the circumstances in which information must be conveyed from one system to another and by whom.

Problems that battle staff members encountered during mission planning support the conclusion that TTPs are needed to improve the management of graphic information. As discussed earlier, battle staff members reported that there is a need for TTPs that specify how best to (a) identify the command level at which graphics were created, (b) deconflict graphics created at different command levels, and (c) process changes in graphics. Although some procedures were suggested by the battle staff members (e.g., a free text message attached to each graphics file), more study is needed to determine whether or not it is possible to develop effective graphics management TTPs without changes in the digital-system hardware, software, or both.

<u>Mission Execution TTPs</u>

The analysis of voice communication events provides compelling evidence of two closely related information management problems. First, the workload associated with processing incoming and outgoing information was often very high and was not evenly distributed among battle staff members. When the volume of communication events was highest, the CO usually was the originator and the recipient of the vast majority of communication events. Second, many instances were observed in which a battle staff member (usually the BC) was the recipient of important information that was not overtly conveyed to the CO. These findings support the conclusion that there is a pressing need for TTPs that specify information management procedures and responsibilities.

The overriding objective of the information management TTPs should be to provide the CO with the information needed to maintain a high level of situation awareness <u>while keeping the CO's information processing workload at a manageable level</u>. It has been suggested that an "information manager" is needed to unburden the CO and perhaps other members of the battle staff as well. However, as is discussed in a later subsection, this study provided no evidence that

adding an "information manager" to the battle staff is the best way to improve the management of information during mission execution. Contemporary information theory (Kahan and Worley, 1989; Schmitt et al., 1994) and the findings of this study support the conclusion that improved information management can best be achieved by establishing TTPs that govern the information management activities and responsibilities of existing battle staff members. Although additional study is required to develop effective information management TTPs, it seems certain that the TTPs must promote the following:

- ensure that the responsibility for monitoring information systems (including but not limited to voice communication systems) is distributed as evenly as possible among members of the battle staff,
- ensure that incoming information is screened by the battle staff members who are responsible for monitoring the information systems,
- ensure that the CO's information needs are anticipated by the battle staff members who are responsible for monitoring the information systems, and
- ensure that only the information that the CO needs to remain situationally aware is transmitted (pushed) to the CO.

Both the CO and XO reported that the information they needed often was not displayed on the large-format (wall mounted) display or was obscured by a pull-down menu or by another window (e.g., message window). It often was necessary for the CO or XO to spend time instructing operators to change the display, eliminate pull-down windows, scroll to a different area, or zoom in/out on an area. These problems support the conclusion that TTPs are needed to govern the following:

- selecting the system display (ASAS, MCS, etc.) that appears on the large format display,
- displaying pull-down menus and other windows,
- scrolling to the area that is of interest to the CO, and
- displaying the imagery at the most suitable magnification level.

The problems that battle staff members encountered in managing graphics information during mission planning (see above description) also were encountered during mission execution. Hence, it is concluded that TTPs governing graphic management must be suitable for use during both mission planning and mission execution. As stated above, the TTPs must establish methods for identifying the command level at which graphics were created, deconflicting graphics, and processing changes to graphics. For mission execution, it is particularly important that the TTPs specify methods for alerting personnel at all command levels that a change in graphics has been made. Because of the high workload imposed on most battle staff members during mission execution, it is unrealistic to expect that changes in graphics would be detected in a reliable and timely manner without an alerting cue of some type.

TTPs for Monitoring Execution of DST

One of the requirements listed in the introductory section of this report was to develop TTPs for monitoring the execution of the DST utilizing digital C^4I systems. This study yielded

little information that bears on this requirement. Although a DST was developed during the planning of each mission, there was no evidence that the CO or any other battle staff member monitored the execution of the DST during the execution of any mission. No overt actions or comments were observed indicating that the CO's review of options or his decisions were keyed to the location of friendly or enemy forces relative to pre-planned decision points (DPs), target areas of interest (TAIs), named areas of interest (NAIs), or time-phase lines.

This study yielded no specific information about the problems that battle staff members encounter when monitoring the execution of a DST. However, other information gained from the study can be used to speculate about the general design requirements for TTPs that would remediate problems that are likely to be encountered. The requirements discussed below follow from the assumptions that the TTPs must be designed to minimize the information processing burden imposed on the battle staff, especially the information processing burden imposed on the CO.

First, the TTPs that govern DST monitoring should minimize the requirements for battle staff members to remember the location of DPs and the events that trigger the CO to review options or to make decisions. This could be accomplished by producing a special graphic overlay (for one or more of the digital systems) that depicts all or most of the information contained on a conventional, hard-copy DST.

Second, the TTPs should ensure that responsibility for monitoring the execution of the DST is shared by two or more battle staff members. It is well known that monitoring tasks are performed poorly by human operators, especially when they must perform other information processing tasks concurrently. It is for this reason that the TTPs should ensure that monitoring the execution of the DST is not the sole responsibility of one battle staff member.

Third, the TTPs should ensure that monitoring the execution of the TTP does not impose an excessive workload on the battle staff members to whom the monitoring task is assigned. One approach to meeting this requirement is to relieve the battle staff members of all responsibilities other than monitoring the execution of the DST. Another approach is to subdivide the monitoring task into elements and distribute the elements among two or more battle staff members. For example, the FSO and/or S2 could be given responsibility for monitoring the DPs that trigger supporting fires. Similarly, the S1 and S4 could be given responsibility for monitoring the DPs that trigger the displacement of a support area or the delivery of supplies. If the monitoring task is subdivided in this manner, it may be desirable to tailor a unique decision support graphic for each battle staff member who has responsibility for monitoring and for the digital system used by the battle staff member.

Finally, the TTPs should ensure that battle staff members who monitor the execution of the DST alert the CO in a timely manner when events have occurred that trigger option evaluation and decision making. The TTPs must establish rules that specify when the CO is to be alerted. The rules may be defined in terms of elapsed time, the proximity of friendly or enemy forces to a specified location, the reaction of enemy forces to a friendly attack, and so on.

The TTP requirements outlined above assume that the monitoring of the execution of the DST must be accomplished manually. It is possible that one or more of the digital C^4I systems could be programmed to signal the operator when events have occurred that trigger a DP. No attempt has been made to assess the feasibility of automating all or a part of the DST execution monitoring function.

Administrative TTPs

Problems reported by battle staff members support the conclusion that TTPs are needed to accomplish the following:

- ensure that all information from prior missions has been removed from the digital systems,
- ensure that all echelons employ a common file-naming method and a common date-time labeling method, and
- ensure that all files transferred among systems or echelons are accompanied by a free text message that describes the contents of the file.

Need for an Information Manager

One of the requirements for this study was to determine whether or not an information manager is needed in the ATCCS and, if so, who that person should be. Battle staff members were questioned about the need for an information manager through questionnaire items and post-exercise interviews. Although nearly one-half of the battle staff members indicated that an information manager is needed, they held widely different views about the function of an information manager.

The most common function mentioned was that of a technical expert who would keep the digital systems running and would provide direct support in operating the systems. The findings of this study support the conclusions that (a) several individuals are needed to serve as digital system maintainers and operators, and (b) an individual is needed to monitor the situation and to pass information about the friendly situation and enemy situation along to the battle staff members who are engaged in mission planning.

This study provided no evidence to support the conclusion that it would be feasible or beneficial to add a battle staff member who would be solely responsible for evaluating incoming information and deciding who should receive the information. The CO stated that information management is one of the CO's primary responsibilities. However, both the CO and XO expressed the view that digital system operators could be and should be trained to screen incoming information and to "push" important information to the CO.

Configuration of C^4I System Displays

Among the requirements that were the impetus for this study was the requirement to "develop a recommended C^4I system display configuration which best supports the commander's information requirements." Because of the constraints discussed above, it was not possible to

develop and assess alternative C^4I system display configurations during this study. The only information compiled during this study that bears on this requirement is a list of the problems that battle staff members encountered in using the display formats. Hence, inferences about a near-optimal C^4I system display configuration must be drawn from a consideration of (a) the problems that battle staff members encountered during this study and (b) the human factors design principles that apply to information displays.

Described below are digital C^4I display system requirements that were inferred from the information compiled during this study and from relevant human factor design principles. Some requirements extend beyond the formatting of information on digital C^4I system displays, but all are aimed at providing the information that the CO needs to establish and maintain a high level of situation awareness during the execution of a mission.

Display Resolution

As was discussed earlier, there were many instances in which the battle staff members were unable to discriminate important information that was portrayed on the large-format wall mounted display. Close inspection by members of the research staff led to the conclusion that the single most important reason for the inadequate discriminability was the fact that alphanumeric characters and point symbols were depicted with too few raster lines. However, inadequate height of some symbols and inadequate figure ground contrast also contributed to problems in discriminating characters and point symbols.

Research has shown that a character height of about 20 min of arc portrayed with 10 raster lines (per symbol height) is required to achieve a character resolution accuracy of about 80% (Baker and Nicholson, 1967; Hemingway and Erickson, 1969). The requirements for symbol subtense and raster lines per symbol height are greater for some symbols and for off-axis viewing of the display. It should also be noted that the minimum character height and the minimum number of raster lines per character height vary as a function of character stroke width, display brightness, brightness contrast, color contrast, and various types of display aberrations. The relationships between such display design variables and display legibility are described in human factors design handbooks and engineering data handbooks (for example, see Boff and Lincoln, 1988).

The development of display design specifications to insure adequate legibility of the C^4I system displays that are to be used by the CO and other battle staff members is beyond the scope of this study. Such an effort would require an assessment of alternate display types (e.g., head-mounted displays, desk-mounted displays, wall-mounted displays) and a human factors design requirements analysis for the display type that is judged optimal. The human factors design requirements analysis must be based on a consideration of the viewing distance, the ambient lighting conditions, display vibration, and the full range of characters and symbols to be displayed.

Size of Point and Linear Symbols

Battle staff members reported that the linear symbols depicted on the displays often were so large that they obscured an excessive amount of map detail. Although no battle staff member reported that point symbols were too large, it seems certain that some of the point symbols depicted on the ASAS and MCS were large enough to obscure important map detail. Research is needed to assess at least three approaches to reducing the obscuration of map detail by point and linear symbols. The research should assess the feasibility of using these approaches singly or in combination to encode and portray linear and point symbols on a C^4I system display.

The most obvious approach is to simply reduce the width of linear symbols and reduce the diameter of point symbols. The amount that symbol size can be reduced and still be easily legible depends on all of the factors discussed above that influence display resolution. The width of linear symbols often can be reduced by a substantial amount and still remain legible. However, a lessor reduction in width is possible if the linear symbol must be discriminated from another linear symbol (e.g., a dotted line vs. a dashed line). The same comments apply to point symbols. A very small point symbol can be detected, but a larger size is required if it is necessary to discriminate among point symbols (e.g., a circle vs. a triangle).

A second approach is to color code point and linear symbols rather than shape code them. Very narrow linear symbols can be differentiated if they are depicted in a different color. An even greater size reduction in point symbols is possible if they are color coded rather than size coded.

A third approach is to provide the operators with the capability to temporarily remove linear symbols or point symbols that obscure important map detail. Ideally, the digital systems would be programmed to enable operators to temporarily remove a single symbol, all symbols of a specified class, or all symbolic information depicted on a C^4I system display.

Map Scale and Map Detail

Throughout a mission, the CO frequently changed the size of the area that appeared on the situation display that he was using (usually the MCS). Similarly, the map detail that was of interest to the CO varied throughout a mission. The CO's need for a larger or smaller viewing area was nearly always closely related to the level of map detail that was of interest to him. When he was interested in viewing a very small area of the battlefield, the CO was interested in the type of map detail that appears on a large-scale map. When he was interested in viewing a large area of the battlefield, the CO had no interest in the map detail that appears on a large-scale map. Rather, he was interested in getting a clear picture of the location of friendly forces and enemy forces relative to one another and/or relative to large topographic features.

When the topographic database remained the same, zooming in on a small area did not increase the amount of map detail that was visible. Zooming in did nothing more than magnify the size of map features, which usually could be discriminated without zooming in on them. Access to greater map detail was possible only by changing the database to one that was compiled at a larger scale, a change that is often too time consuming.

The problems encountered by the CO and other battle staff members point to the need for a system that displays progressively more map detail as the user zooms in on an area of interest and, conversely progressively less map detail as the user zooms out. Providing such a capability is not an easy task. It would be necessary to develop software that selects different classes of topographic features for portrayal depending on the size of the area portrayed. The software also would have to change the rules of topographic feature generalization as a function of changes in the size of the area portrayed.

The S2 recommended what may be a more feasible solution to this problem. He recommended that the CO be provided with duplicate systems that are the same in all respects except the scale of the topographic database that is loaded in the systems. One system would be loaded with a large-scale database (e.g. 1:50,000-scale) and the other system would be loaded with a smaller scale database (e.g., 1:250,000-scale). Although this solution may increase the requirements for equipment, space, and personnel, it is technically feasible at the present time.

Clutter Control

The CO and XO reported that (a) their need for symbolic information does not remain constant throughout a mission and (b) portraying all the symbolic information that is needed at some point during a mission results in excessive display clutter. These observations point to the need for a convenient way to control display clutter by displaying only the symbolic information that is needed for the mission phase that is underway. Although most digital systems enable the operator to add or remove different classes of symbolic information, it would be excessively time consuming and distracting for the CO or another battle staff member to evaluate and to modify symbolic information throughout a mission. A logically appealing approach proposed by the XO was to develop a small set of symbolic information formats that, together, would meet the CO's needs throughout the mission. The symbolic information formats could be developed to fulfill the information needs during each mission phase, during special situations, or both.

Deaggregation of Friendly and Enemy Unit Icons

The CO indicated that the use of regimental icons to depict the location of enemy forces is not adequate for some situations and for some users. He stated that digital C^4I display systems should enable the CO and other battle staff members to deaggregate the regiment icons into the companies that comprise the regiment. That is, icons would be displayed showing the locations of the companies that comprise the regiments. Although not stated by the CO, it is assumed that the regimental icons would be preferred under some circumstances. If this assumption is correct, the digital C^4I display systems should enable the user to both aggregate and deaggregate the icons that depict the location of enemy units.

Identification "Tags" for Friendly Aircraft Symbols

The data compiled during this study confirmed the well-known fact that maintaining an awareness of the location of friendly aircraft is a vital part of the CO's situation awareness. It is also a well-known fact that one of the most important requirements of digital C^4I display systems is to provide accurate and current information about the location of individual friendly aircraft.

The XO suggested that the effectiveness of a system that tracks and displays the location of friendly aircraft would be improved dramatically if identification "tags" could be attached to the friendly aircraft icons. There is no doubt that the capability to attach identification "tags" to friendly aircraft icons is a highly desirable requirement for a digital C^4I display system.

Coding of Threat Icons

Problems reported by the CO and XO point to the need for a better system for encoding the threat icons that depict threat vehicles. One need is for the capability to modify the icons in a way that depicts the age of the intelligence information that was used to depict a threat icon at a specific location. For instance, the XO suggested that the color, shape, or brightness of a threat icon could be changed systematically to reflect the age of the intelligence information that was used to establish the location of the threat. A similar requirement is for a capability to employ a coding system for threat icon that depicts whether the threat is active or has been destroyed. Although an important requirement for digital C^4I display systems, research is needed to determine the optimal method for encoding threat icons to reflect the currency of intelligence information on which they are based and the status (active or destroyed) of the threat.

Lessons Learned About Research Methodology

Some of the lessons learned about the methodology used in this study are discussed below.

Prior Training of Battle Staff Members

The small amount of training that battle staff members received on the functions and operation of the digital systems has been mentioned repeatedly throughout this report. Although a necessary constraint, it must be acknowledged that more could have been learned about how best to use the digital equipment (TTPs) if battle staff members had received more training prior to the start of the study. In future studies of this type, every attempt should be made to acquire the time and resources needed to provide battle staff members with more comprehensive training on the functions and operation of the digital systems.

Realism of Mission Scenarios and Scheduling

For the most part, the battle staff members indicated that the mission scenarios and the scheduling of exercises were quite realistic. Battle staff members suggested that realism could be improved by increasing the volume of intelligence information that must be processed during mission planning and during mission execution. The low volume of intelligence information caused the workload of some battle staff members to be unrealistically low. Battle staff members also reported that improvements in realism could be achieved by making the S1 and S4 perform a more realistic number of the tasks they ordinarily perform during mission planning and mission execution.

There were numerous reports that an inadequate amount of time was made available for mission planning. In one instance, the time between the receipt of a FRAGO and aircraft launch

was clearly insufficient for adequate mission planning. Other reports of inadequate planning time probably were due more to the battle staff's lack of training than to the absolute amount of time that was available for mission planning.

Identification of Mission Planning Problems/Oversights

The mission planning questionnaire completed by the battle staff members did not prove to be an effective way to obtain detailed information about the mission planning problems and oversights. Although some battle staff members took the time to write a description of mission planning problems and oversights, most did not. The reluctance to draft written descriptions of problems was not altogether unexpected.

The mission planning observations proved to be an even less effective method for obtaining detailed information about mission planning problems and oversights. Although the mission planning observers were reasonably knowledgeable about the MDMP steps and substeps, they were unable to identify and describe the MDMP steps/substeps that were not performed adequately, much less the reasons for inadequate performance.

It seems unlikely that either the questionnaire items or the observation procedures could be modified to provide detailed and comprehensive information about mission planning problems/oversights. In future studies of this type, consideration should be given to face-to-face interviews with individual battle staff members as a means of obtaining detailed information about mission planning problems/oversights. Some mission planning problems/oversights do not become apparent until after a mission has been executed. Therefore, interviews to identify specific mission planning problems and oversights are likely to be most effective if they are conducted immediately after the mission has been executed.

Identification of TTPs

An observation study is not an effective way to identify near-optimal TTPs for using digital C^4I systems. Even if the battle staff members had received comprehensive training on the digital systems, this study would have yielded information about only one set of TTPs, which may have been highly effective or highly ineffective. Near-optimal TTPs can be identified with certainty through an experimental study in which performance is measured as TTPs are varied systematically. The only alternative to an experimental study is to convene a team of SMEs to discuss alternate TTPs and to adopt the TTPs that the SMEs judge to be best. Thereafter, the TTPs could be employed in training exercises and refined when necessary.

Another observation worth noting is that neither the battle staff members nor the members of the research staff have a clear understanding of the meaning of the term TTPs. No official definition of TTPs has been located in any Army document. The findings of this study support the conclusion that an official definition of the term TTP should be developed or use of the term should be abandoned.

Use of Mission Planning Time as a Measure of Proficiency

For many tasks, the time to perform the task is a valid measure of task proficiency. The present study indicates that the amount of time required to perform the MDMP steps, individually or collectively, is not a reliable measure of the proficiency of the battle staff members who participate in mission planning. The reason is that many factors other than proficiency influence the amount of time spent performing the MDMP steps. Perhaps the most important factor is the battle staff members' inclination to always use all of the planning time that is available. Another factor is that the characteristics of the mission being planned have an enormous influence in the amount of time that is required to plan the mission. For these reasons and others, the time spent planning a mission cannot be expected to serve as a valid predictor of the proficiency of the mission planning staff.

Improvements in Mission Execution Observations

This study showed that passive observation by relatively inexperienced observers can yield a great deal of useful information about the activities and problems that occur during mission execution. However, there are ways to improve the information that is recorded by the observers. One way is to replace the voice communication system used in this study with a system in which headphones rather than speakers are used. With speakers, it is impossible for observers to track the flow of information to and from each battle staff member. That is, it is impossible for observers to determine the battle staff members who hear messages that are announced over the speakers.

Additional training of observers is needed to improve their ability to recognize key events and problems that occur during mission execution. For example, additional training probably would increase observers' ability to recognize and record key decision points that occurred during the mission and instances of heavy workload. However, it seems unlikely that additional training would significantly improve observers' ability to recognize decision errors, problems encountered in operating the digital equipment, and problems encountered in interpreting the digital system displays. With few exceptions, the information needed to recognize such problems is not available to a passive observer. These findings support the conclusion that other methods are needed to identify the various problems that battle staff members encounter during mission execution.

Analysis of Communication Events

The findings of this study support the conclusion that the analysis of voice communication events yields valuable information about information management problems, the absolute and relative workload of battle staff members, and the command style of the CO. Although very labor intensive, the recording and analysis of communication events is highly recommended for future research on the use of digital C^4I systems.

It is also recommended that time and resources are invested to develop equipment to automate all or a part of communication event recording and analysis. The automation of communication event recording and analysis would greatly increase the effectiveness of future

research on the use of digital C^4I systems. Of equal importance, automation of communication event recording and analysis would enable training personnel to provide feedback that should enhance trainees' information management techniques and their command style. Such feedback should be of enormous value for training digital system operators to screen incoming information and to "push" relevant information to the CO.

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APPENDIX A

INFORMED CONSENT AGREEMENT
AND
DEMOGRAPHIC QUESTIONNAIRE

COMPLETED BY ALL INDIVIDUALS WHO SERVED AS A MEMBER OF THE BATTLE STAFF IN THE ATCCS

DIGITIZED TOC STUDY
Army Tactical Command and Control System in the Aviation Battalion Tactical Operations Center

US ARMY RESEARCH INSTITUTE ROTARY WING AVIATION RESEARCH UNIT, FORT RUCKER, ALABAMA

CONSENT FORM

INTRODUCTION: This project is part of a Training and Doctrine Command (TRADOC) sponsored one-year project conducted under the Army Research Institute (ARI) Study and Analysis Program, Work Package 2151. The study is titled FORCE XXI AVIATION BATTLE STAFF TRAINING: INTEGRATION OF C4I INTO BATTLE SIMULATION. The major objective of the study is to define methods by which lessons learned from Advanced Concept Technology Demonstrations, Advanced Warfighting Experiments, and other exercises relating to training and operations issues of Command, Control, Communications and Computer Integration (C4I), may be incorporated into battle staff training more rapidly through constructive and virtual simulation. Within the ATCCS simulation exercise the digitized C4I system will be operated to discover opportunities for improvements to information management for decision making. Emphasis will be on the processes for developing a tactical Course Of Action and Decision Support Template. It will also be evaluated to define and designate an operations information management role.

DISCLOSURE: Your activities will include functioning as a member of an Aviation Battalion Battle Staff during simulated Brigade operations. We will measure various aspects of your performance in the simulator during the tactical scenarios. You will be asked to complete a questionnaire that will record information regarding your background, training and work-related experience. In addition, you will be asked to complete other survey type forms to record your experiences with the ATCCS and your impressions regarding training benefits.

RISK: No physical or emotional risks have been identified in this research protocol. The level of stress generated by participation in this research is expected to be minimal. There are no hidden measures or hidden purposes within this study. Nor is there any deception used in this research protocol.

CONFIDENTIALITY: All information will be kept in strictest confidence. Only group summary results will ever be discussed or reported. No personally identifiable information will be used in reporting results of this project to any agency, either within or outside the US Army. Individuals and units participating in this research will remain anonymous. YOU HAVE THE RIGHT TO REFUSE TO PROVIDE ANY OR ALL INFORMATION WITHOUT RISK OF ANY NEGATIVE CONSEQUENCE TO YOU. This right is protected under provisions of *AR 70-25 Use of Volunteers as Subjects of Research.*

ACKNOWLEDGMENT: By signing below I acknowledge that I have been informed that I have the right to refuse to provide any or all information asked of me. I further acknowledge that I have been informed that any and all information that I choose to provide will be kept anonymous.

________________________________ ________________

Signature Date

POINT OF CONTACT:

Dr. William R. Howse
ARI-RWARU
PERI-IR
Bldg. 5100
Fort Rucker AL 36362-5354
334-255-3686 DSN 558-3686

[ARI-RWARU KEEPS ONE COPY. PARTICIPANT KEEPS ONE COPY.]

Participant Questionnaire

The purpose of this questionnaire is to obtain information about the training and experience that you bring to Digital Tactical Operations Center (TOC) Study. Information about the training and experience of participants is essential for establishing the credibility of the research findings, conclusions, and recommendations.

1. Name ______________________________

2. Age ________ 3. Current Grade _______ 4. Duty Phone ________________

5. Unit Address ______________________________

6. What is your assigned battle staff position(s) in this study? ____________________

____

7. What is your Specialty Skill Identifier (SSI) or your Primary Occupational Specialty (PMOS)?
   SSI ____________________
   PMOS ____________________

6. How many years of military service do you have?
   _______ years Active Component Service
   _______ years Reserve Component Service

7. What is your current duty assignment?

____

____

8. How long have you served in your present duty assignment?
   ____months

9. List the military education courses you have completed.

____

____

____

____

10. List the military technical schools you have completed.

____

____

____

____

11. List the number of months you have served in each of the following battle staff positions. (Enter "0" if none.)
   ________ months experience as battalion commander
   ________ months experience as battalion XO
   ________ months experience as battalion S1
   ________ months experience as battalion S2
   ________ months experience as battalion S3
   ________ months experience as battalion S4
   ________ months experience as battalion FSO
   ________ months experience as battalion ADO
   ________ months experience as battalion UAV operator
   ________ months experience as battalion JSTARS operator
   ________ months experience as battalion ASAS operator
   ________ months experience as battalion AFATDS operator
   ________ months experience as battalion MCS/P operator
   ________ months experience as battalion AMDWS operator
   ________ months experience as battalion FAADEO operator

12. Indicate your level of knowledge about the functional capabilities of each of the following digital system.

	High		Moderate		None
JSTARS	[ ]	[ ]	[ ]	[ ]	[ ]
ASAS	[ ]	[ ]	[ ]	[ ]	[ ]
AFATDS	[ ]	[ ]	[ ]	[ ]	[ ]
MCS/P	[ ]	[ ]	[ ]	[ ]	[ ]
FAADEO	[ ]	[ ]	[ ]	[ ]	[ ]

13. Indicate your level of skill in operating of each of the following digital system.

	High		Moderate		None
JSTARS	[ ]	[ ]	[ ]	[ ]	[ ]
ASAS	[ ]	[ ]	[ ]	[ ]	[ ]
AFATDS	[ ]	[ ]	[ ]	[ ]	[ ]
MCS/P	[ ]	[ ]	[ ]	[ ]	[ ]
FAADEO	[ ]	[ ]	[ ]	[ ]	[ ]

APPENDIX B

Mission Planning Questionnaire

Name ______________________________ **Today's Date** __________

Your battle staff position in today's exercise ______________________________

1. About how much time did you spend planning today's mission?
   _____ hours and __ minutes

2. How difficult was it to plan this mission compared with an operational mission of the same type? (check one)
   [ ] much easier
   [ ] somewhat easier
   [ ] about the same
   [ ] somewhat more difficult
   [ ] much more difficult
   [ ] don't know

3. Describe ways in which the planning of today's mission was <u>more difficult</u> and the ways it was <u>less difficult</u> than the planning of an operational mission of the same type.
   Ways more difficult ______________________________
   ____
   ____
   ____

   Ways less difficult ______________________________
   ____
   ____
   ____

4. Please rate the <u>realism</u> of today's mission compared with a similar operational mission.
   [ ] highly unrealistic
   [ ] moderately unrealistic
   [ ] highly realistic
   [ ] don't know

   Describe the ways in which today's mission was <u>at least moderately unrealistic</u> (compared with a similar operational mission).
   ____
   ____
   ____
   ____
   ____

The following section includes items that ask you to rate the adequacy of the time available and information available to perform each step in the Military Decision Making Process (MDMP). This section also includes items that ask you about the problems you encountered in performing these steps and potential solutions to these problems. When responding to these items, please refer to the attached list to jog your memory about the general and specific steps in the MDMP.

5. Please rate the adequacy of the <u>time available</u> to perform each of the following steps of the MDMP.

	Adequacy of Time		
General Steps	*Adequate*	*Inadequate*	*Did Not Perform*
Receive the Mission	[ ]	[ ]	[ ]
Analyze the Mission	[ ]	[ ]	[ ]
Development of COA	[ ]	[ ]	[ ]
Analyze the COA (War Game)	[ ]	[ ]	[ ]
Compare the COA	[ ]	[ ]	[ ]
Approve the COA	[ ]	[ ]	[ ]
Produce the Orders	[ ]	[ ]	[ ]

6. Please rate the adequacy of the <u>information available</u> to perform each of the following steps of the MDMP.

	Adequacy of Information		
General Steps	*Adequate*	*Inadequate*	*Did Not Perform*
Receive the Mission	[ ]	[ ]	[ ]
Analyze the Mission	[ ]	[ ]	[ ]
Development of COA	[ ]	[ ]	[ ]
Analyze the COA (War Game)	[ ]	[ ]	[ ]
Compare the COA	[ ]	[ ]	[ ]
Approve the COA	[ ]	[ ]	[ ]
Produce the Orders	[ ]	[ ]	[ ]

7. At times, the information needed to perform a MDMP step is available in the system but is difficult to extract from the system. In other words, the information is available but not easily accessible. Please rate the <u>accessibility</u> of the information needed to perform each of the following steps of the MDMP.

	Accessibility of Information		
General Steps	*Adequate*	*Inadequate*	*Did Not Perform*
Receive the Mission	[ ]	[ ]	[ ]
Analyze the Mission	[ ]	[ ]	[ ]
Development of COA	[ ]	[ ]	[ ]
Analyze the COA (War Game)	[ ]	[ ]	[ ]
Compare the COA	[ ]	[ ]	[ ]
Approve the COA	[ ]	[ ]	[ ]
Produce the Orders	[ ]	[ ]	[ ]

8. Please rate the highest level of workload that you experienced when performing each of the following steps of the MDMP.

General Steps	*Your Workload Level* *Very High*	*High*	*Moderate*	*Too Low*	*Did Not Perform*
Receive the Mission	[ ]	[ ]	[ ]	[ ]	[ ]
Analyze the Mission	[ ]	[ ]	[ ]	[ ]	[ ]
Development of COA	[ ]	[ ]	[ ]	[ ]	[ ]
Analyze the COA (War Game)	[ ]	[ ]	[ ]	[ ]	[ ]
Compare the COA	[ ]	[ ]	[ ]	[ ]	[ ]
Approve the COA	[ ]	[ ]	[ ]	[ ]	[ ]
Produce the Orders	[ ]	[ ]	[ ]		

9. For today's mission, were errors or oversights made in performing any of the MDMP steps?

General Steps	*Errors or Oversights?* *Yes*	*No*	*Did Not Perform*
Receive the Mission	[ ]	[ ]	[ ]
Analyze the Mission	[ ]	[ ]	[ ]
Development of COA	[ ]	[ ]	[ ]
Analyze the COA (War Game)	[ ]	[ ]	[ ]
Compare the COA	[ ]	[ ]	[ ]
Approve the COA	[ ]	[ ]	[ ]
Produce the Orders	[ ]	[ ]	[ ]

If you answered yes to any of the above, please describe below each error or oversight that was made and identify the MDMP step in which it was made.

____

____

____

____

10. For today's mission, did lack of familiarity with the operation or functional capability of equipment in the digital TOC make it more difficult to perform any of the MDMP steps?

General Steps	*More Difficult?* *Yes*	*No*	*Did Not Perform*
Receive the Mission	[ ]	[ ]	[ ]
Analyze the Mission	[ ]	[ ]	[ ]
Development of COA	[ ]	[ ]	[ ]
Analyze the COA (War Game)	[ ]	[ ]	[ ]
Compare the COA	[ ]	[ ]	[ ]
Approve the COA	[ ]	[ ]	[ ]
Produce the Orders	[ ]	[ ]	[ ]

If you answered yes to any of the above, identify the equipment for which you lacked adequate familiarity and the MDMP steps that were influenced. ______________

____

____

____

11. For today's mission, were any of the TTPs inadequate for performing the MDMP steps in a digital TOC?

General Steps	TTPs Inadequate? Yes	No	Did Not Perform
Receive the Mission	[ ]	[ ]	[ ]
Analyze the Mission	[ ]	[ ]	[ ]
Development of COA	[ ]	[ ]	[ ]
Analyze the COA (War Game)	[ ]	[ ]	[ ]
Compare the COA	[ ]	[ ]	[ ]
Approve the COA	[ ]	[ ]	[ ]
Produce the Orders	[ ]	[ ]	[ ]

If you answered yes to any of the above, identify the additional or modified TTPs that are needed and the MDMP steps that would be improved. ____________________

____

____

____

____

12. For today's mission, is more automation needed to perform adequately the MDMP steps in a digital TOC? Check "yes" if more automation is needed to perform the step with sufficient accuracy, comprehensiveness, speed, or some combination of these.

General Steps	Automation Needed? Yes	No	Did Not Perform
Receive the Mission	[ ]	[ ]	[ ]
Analyze the Mission	[ ]	[ ]	[ ]
Development of COA	[ ]	[ ]	[ ]
Analyze the COA (War Game)	[ ]	[ ]	[ ]
Compare the COA	[ ]	[ ]	[ ]
Approve the COA	[ ]	[ ]	[ ]
Produce the Orders	[ ]	[ ]	[ ]

If you answered yes to any of the above, identify the additional automation that is needed and the MDMP steps that would be improved. ____________________

____

____

____

____

13. In your view, is there a need to add a staff member to the battalion whose sole responsibility is to manage the flow of information in a digital TOC during mission planning.

[ ] No

[ ] Yes

If yes, please describe as specifically as you can the duties and responsibilities of an information manager. ____________________

____

____

____

____

14. Please rate the adequacy of your prior training for performing each of the following MDMP steps in a digital TOC.

General Steps	*Adequacy of Training* *Adequate*	*Inadequate*	*Did Not Perform*
Receive the Mission	[ ]	[ ]	[ ]
Analyze the Mission	[ ]	[ ]	[ ]
Development of COA	[ ]	[ ]	[ ]
Analyze the COA (War Game)	[ ]	[ ]	[ ]
Compare the COA	[ ]	[ ]	[ ]
Approve the COA	[ ]	[ ]	[ ]

If you checked inadequate for any of the MDMP steps, describe the additional training that you believe you need. ______________________________

____

____

____

____

Your answers to the above questions are extremely valuable; your inputs are greatly appreciated by all members of the research team. If you have other insights that bear on these questions (now or in the future), please contact Dr. William Howse (334) 255-3686.

STEPS IN THE MILITARY DECISION MAKING PROCESS
(By Battle Staff Member)

STEPS IN MILITARY DECISION MAKING PROCESS
1. RECEIVE THE MISSION
1. Issue a WO to staff personnel
2. Determine initial timelines
3. Issue initial commander's guidance
Receive initial commander's guidance
4. Issue a WO to subordinates and support units

STEPS IN MILITARY DECISION MAKING PROCESS
2. ANALYZE THE MISSION
1. Review the higher headquarters order
Determine staff priorities/stds & coordinate mission analysis
Review known enemy and friendly situations
2. Conduct initial IPB
3. Determine specified, implied, and essential tasks
4. Determine the area of interest (and intent)
5. Review available assets
6. Determine constraints
Determine and maintain the status of personnel
Determine and maintain the logistic status
Determine FS asset allocation status
Determine air defense warning status
7. Identify critical facts and assumptions
8. Conduct risk assessment
9. Determine initial commander's critical information reqts.
Forecast and examine personnel reqts. previously identified
Identify areas for which the commander is responsible
Compare higher hqs. order FA data to AFATDS data
Determine status of fire units that are providing protection
Identify friendly vulnerabilities and limitations
Determine capabilities of available FA assets and ammo
10. Determine the initial reconnaissance plan
Coordinate external logistics support
Refine timelines
Determine liaison requirements
Identify users and uses of airspace
Identify A2C2 measures imposed by higher hqs.
11. Plan use of available time
12. Write the restated mission
13. Conduct a mission analysis briefing
Receive mission analysis briefing
14. Approve the restated mission
15. Develop the commander's intent
Receive commander's intent and planning guidance
16. Issue the commander's guidance
17. Issue a WO to subordinate and supporting units
18. Review facts and assumptions

STEPS IN MILITARY DECISION MAKING PROCESS
3. DEVELOPMENT OF COA
Conduct direct coordination with supported ground cdrs.
1. Analyze relative combat power
Define the most probable and most dangerous enemy COAs
2. Generate options
3. Array initial forces
4. Develop a scheme of maneuver
Describe the effects of the AO and enemy situation on COA
5. Determine C2 means
Conduct COA briefing
Receive COA briefing
6. Prepare COA statements and sketches

STEPS IN MILITARY DECISION MAKING PROCESS
4. ANALYZE THE COA (WAR GAME)
1. Gather the tools
2. List all friendly forces
3. List assumptions
4. List known critical events and decision points
5. Determine evaluation criteria
6. Select the war-game method
7. Select a method to record and display results
8. War game the battle and assess the results
Refine COA
Identify key or decisive terrain and determine how to use it
Determine task organization
Identify tasks the unit must retain and tasks to be assigned
Develop a synchronization matrix
Develop decision support template
Estimate the duration of each critical event operation
Identify location and commitment of the reserve
Identify the location of the cdr. and unit CPs
Identify additional critical events
Determine requirements for deception and surprise
Determine C2 requirements
Determine timing of force concentration and attack
Determine movement times and tables
Develop SEAD plan
Integrate the targeting process
Identify risks, determine acceptable risks, & risk avoidance
Project the percentage of total enemy forces defeated
Identify likely times and areas for enemy use of WMD
Refine CCIR and incorporate into the R&S plan/graphics
Identify and/or confirm the locations of decision points
Develop the intelligence collection and dissemination plan
Integrate the targeting process
Develop scheme of fires
Develop execution matrix
Develop target template/target list worksheet
Develop fire support overlay
Allocate combat, Cs, and CSS assets to subordinate cdrs.
Develop AD plans/graphics
Develop CSS plans/graphics

STEPS IN MILITARY DECISION MAKING PROCESS
4. ANALYZE THE COA (WAR GAME) (continued)
Identify additional requirements for CS
Develop CSS plans/graphics
Identify/analyze/evaluate strengths and weaknesses of COA
Conduct war game briefing
Receive war game briefing
Assess and manage risk

STEPS IN MILITARY DECISION MAKING PROCESS	
	5. COMPARE THE COA
1.	Analyze and evaluate the advantages and disadvantages
	Determine and consolidate all airspace uses/users/conflicts
2.	Present each staff section's findings
3.	Compare COA utilizing previously defined eval. criteria
	Conduct COA decision brief
	Receive COA decision briefing
4.	Select recommended COA

STEPS IN MILITARY DECISION MAKING PROCESS	
	6. APPROVE THE COA
1.	Conduct commander's decision briefing
2.	Approve COA
3.	Issue commander's guidance
	Repeat portions of steps 3-5, as necessary
4.	Issue WO to subordinate and supporting units

APPENDIX C

Mission Planning Observations Form

Name ______________________________ **Date** ______ **Mission Number** ______

STEP 1. RECEIVE THE MISSION

1. Timing: Step 1 started __________ Step 1 completed __________

2. Check the battle staff members who participated in each Step 1 task.

	CDR	XO	S-1	S-2	S-3	S-4	FSO	ADO
1. Issue a WO to staff personnel								
2. Determine initial timelines								
3. Issue initial commander's guidance								
Receive initial commander's guidance								
4. Issue a WO to subordinates and support units								

3. Check the support staff members who participated in Step 1.
   - [ ] S-2 NCO (UAV Operator)
   - [ ] S-2 NCO (ASAS Operator)
   - [ ] S-2 NCO (UAV Operator)
   - [ ] AS-2 (JSTARS Operator)
   - [ ] AFATDS Operator
   - [ ] S-3 NCO (MCS/P Operator)
   - [ ] S-3 NCO (Other)
   - [ ] A S-3
   - [ ] ADO NCO (AMDWS Operator)
   - [ ] ADO NCO (FAADEO Operator)

4. Identify the problems observed in performing Step 1 and the staff member(s) who encountered the problems.

   A. Important information not available ______________________________

   B. Important information not easily accessible ______________________________

   C. Excessive workload ______________________________

   D. Lack of knowledge about functional capabilities of digital equipment ______________________________

   E. Lack of skill in operating digital equipment ______________________________

   F. Inadequate TTPs ______________________________

G. Lack of training/experience on the MDMP ______________________________

H. Other ______________________________

STEP 2. ANALYZE THE MISSION

5. Timing: Step 2 started __________ Step 2 completed __________

6. Check the battle staff members who participated in each Step 2 task.

	CDR	XO	S-1	S-2	S-3	S-4	FSO	ADO
1. Review the higher headquarters order								
Determine staff priorities/stds & coordinate mission analysis								
Review known enemy and friendly situations								
2. Conduct initial IPB								
3. Determine specified, implied, and essential tasks								
4. Determine the area of interest (and intent)								
5. Review available assets								
6. Determine constraints								
Determine constraints								
Determine and maintain the status of personnel								
Determine and maintain the logistic status								
Determine FS asset allocation status, et.al								
Determine air defense warning status								
7. Identify critical facts and assumptions								
8. Conduct risk assessment								
9. Determine initial commander's critical information reqts.								
Forecast and examine personnel reqts previously identified								
Identify areas for which the commander is responsible								
Compare higher hqs order FA data to AFATDS data								
Determine status of fire units that are providing protection								
Identify friendly vulnerabilities and limitations								
Determine capabilities of available FA assets and ammo								
10. Determine the initial reconnaissance plan								
Coordinate external logistics support								
Refine timelines								
Determine liaison requirements								
Identify users and uses of airspace								
Identify A2C2 measures imposed by higher hqs, et.al.								
11. Plan use of available time								
12. Write the restated mission								
13. Conduct a mission analysis briefing								
Receive mission analysis briefing								
14. Approve the restated mission								
15. Develop the commander's intent								
Receive commander's intent and planning guidance								
16. Issue the commander's guidance								
17. Issue a WO to subordinate and supporting units								
18. Review facts and assumptions								

7. Check the support staff members who participated in Step 2.

[ ] S-2 NCO (UAV Operator)
[ ] S-2 NCO (ASAS Operator)
[ ] S-2 NCO (UAV Operator)
[ ] AS-2 (JSTARS Operator)
[ ] AFATDS Operator
[ ] S-3 NCO (MCS/P Operator)
[ ] S-3 NCO (Other)
[ ] A S-3
[ ] ADO NCO (AMDWS Operator)
[ ] ADO NCO (FAADEO Operator)

8. Identify the problems observed in performing Step 2 and the staff member(s) who encountered the problems.

   A. Important information not available ______________________________

   B. Important information not easily accessible ______________________________

   C. Excessive workload ______________________________

   D. Lack of knowledge about functional capabilities of digital equipment ______________________________

   E. Lack of skill in operating digital equipment ______________________________

   F. Inadequate TTPs ______________________________

   G. Lack of training/experience on the MDMP ______________________________

   H. Other ______________________________

STEP 3. DEVELOPMENT OF COA

9. Timing: Step 3 started __________ Step 3 completed __________

10. Check the battle staff members who participated in each Step 3 task.

	CDR	XO	S-1	S-2	S-3	S-4	FSO	ADO
Conduct direct coordination with supported ground cdrs.								
1. Analyze relative combat power								
Define the most probable and most dangerous enemy COAs								
2. Generate options								
3. Array initial forces								
4. Develop a scheme of maneuver								
Describe the effects of the AO and enemy situation on COA								
5. Determine C2 means								
Conduct COA briefing								
Receive COA briefing								
6. Prepare COA statements and sketches								

11. Check the support staff members who participated in Step 3.
- [ ] S-2 NCO (UAV Operator)
- [ ] S-2 NCO (ASAS Operator)
- [ ] S-2 NCO (UAV Operator)
- [ ] AS-2 (JSTARS Operator)
- [ ] AFATDS Operator
- [ ] S-3 NCO (MCS/P Operator)
- [ ] S-3 NCO (Other)
- [ ] A S-3
- [ ] ADO NCO (AMDWS Operator)
- [ ] ADO NCO (FAADEO Operator)

12. Identify the problems observed in performing Step 3 and the staff member(s) who encountered the problems.

A. Important information not available ______________________________

____

____

B. Important information not easily accessible ______________________________

____

____

C. Excessive workload ______________________________

____

____

D. Lack of knowledge about functional capabilities of digital equipment __________

____

____

E. Lack of skill in operating digital equipment ______________________________

____

____

F. Inadequate TTPs ______________________________

____

____

G. Lack of training/experience on the MDMP ______

H. Other ______

STEP 4. ANALYZE THE COA (WAR GAME)

13. Timing: Step 4 started __________ Step 4 completed __________

14. Check the battle staff members who participated in each Step 4 task.

4. ANALYZE THE COA (WAR GAME)	CDR	XO	S-1	S-2	S-3	S-4	FSO	ADO
1. Gather the tools								
2. List all friendly forces								
3. List assumptions								
4. List known critical events and decision points								
5. Determine evaluation criteria								
6. Select the war-game method								
7. Select a method to record and display results								
8. War game the battle and assess the results								
Refine COA								
Identify key or decisive terrain and determine how to use it								
Determine task organization								
Identify tasks the unit must retain and tasks to be assigned								
Develop a synchronization matrix								
Develop decision support template								
Estimate the duration of each critical event operation								
Identify location and commitment of the reserve								
Identify the location of the commander and unit CPs								
Identify additional critical events								
Determine requirements for deception and surprise								
Determine C2 requirements								
Determine timing of force concentration and attack								
Determine movement times and tables								
Develop SEAD plan								
Integrate the targeting process								
Identify risks, determine acceptable risks, & risk avoidance								
Project the percentage of total enemy forces defeated								
Identify likely times and areas for enemy use of WMD								
Refine CCIR and incorporate into the R&S plan/graphics								
Identify and/or confirm the locations of decision points								
Develop the intelligence collection and dissemination plan								
Integrate the targeting process								
Develop Scheme of fires								
Develop execution matrix								
Develop target template/target list worksheet								
Develop fire support overlay								
Allocate combat, Cs, and CSS assets to subordinate cdrs.								
Develop AD plans/graphics								
Develop CSS plans/graphics								
Identify additional requirements for CS								
Develop CSS plans/graphics								
Identify/analyze/evaluate strengths and weaknesses of COA								
Conduct war game briefing								
Receive war game briefing								
Assess and manage risk								

15. Check the support staff members who participated in Step 4.

[ ] S-2 NCO (UAV Operator)
[ ] S-2 NCO (ASAS Operator)
[ ] S-2 NCO (UAV Operator)
[ ] AS-2 (JSTARS Operator)
[ ] AFATDS Operator
[ ] S-3 NCO (MCS/P Operator)
[ ] S-3 NCO (Other)
[ ] A S-3
[ ] ADO NCO (AMDWS Operator)
[ ] ADO NCO (FAADEO Operator)

16. Identify the problems observed in performing Step 4 and the staff member(s) who encountered the problems.

A. Important information not available ____________________

B. Important information not easily accessible ____________________

C. Excessive workload ____________________

D. Lack of knowledge about functional capabilities of digital equipment ____________________

E. Lack of skill in operating digital equipment ____________________

F. Inadequate TTPs ____________________

G. Lack of training/experience on the MDMP ____________________

H. Other ____________________

STEP 5. COMPARE THE COA

17. Timing: Step 5 started __________ Step 5 completed __________

18. Check the battle staff members who participated in each Step 5 task.

	CDR	XO	S-1	S-2	S-3	S-4	FSO	ADO
1. Analyze and evaluate the advantages and disadvantages								
Determine and consolidate all airspace uses/users/conflicts								
2. Present each staff section's findings								
3. Compare COA utilizing previously defined evaluation criteria								
Conduct COA decision brief								
Receive COA decision briefing								
4. Select recommended COA								

19. Check the support staff members who participated in Step 5.
   - [ ] S-2 NCO (UAV Operator)
   - [ ] S-2 NCO (ASAS Operator)
   - [ ] S-2 NCO (UAV Operator)
   - [ ] AS-2 (JSTARS Operator)
   - [ ] AFATDS Operator
   - [ ] S-3 NCO (MCS/P Operator)
   - [ ] S-3 NCO (Other)
   - [ ] A S-3
   - [ ] ADO NCO (AMDWS Operator)
   - [ ] ADO NCO (FAADEO Operator)

20. Identify the problems observed in performing Step 5 and the staff member(s) who encountered the problems.

   A. Important information not available ______________________________

   B. Important information not easily accessible ______________________________

   C. Excessive workload ______________________________

   D. Lack of knowledge about functional capabilities of digital equipment __________

   E. Lack of skill in operating digital equipment ______________________________

   F. Inadequate TTPs ______________________________

   G. Lack of training/experience on the MDMP ______________________________

H. Other

STEP 6. APPROVE THE COA

21. Timing: Step 6 started __________ Step 6 completed __________

22. Check the battle staff members who participated in each Step 6 task.

	CDR	XO	S-1	S-2	S-3	S-4	FSO	ADO
1. Conduct commander's decision brief								
2. Approve COA								
3. Issue commander's guidance								
Repeat portions of steps 3-5, as necessary								
4. Issue WO to subordinate and supporting units								

23. Check the support staff members who participated in Step 6.

[ ] S-2 NCO (UAV Operator)
[ ] S-2 NCO (ASAS Operator)
[ ] S-2 NCO (UAV Operator)
[ ] AS-2 (JSTARS Operator)
[ ] AFATDS Operator
[ ] S-3 NCO (MCS/P Operator)
[ ] S-3 NCO (Other)
[ ] A S-3
[ ] ADO NCO (AMDWS Operator)
[ ] ADO NCO (FAADEO Operator)

24. Identify the problems observed in performing Step 6 and the staff member(s) who encountered the problems.

A. Important information not available ______________________________

B. Important information not easily accessible ______________________________

C. Excessive workload ______________________________

D. Lack of knowledge about functional capabilities of digital equipment __________

E. Lack of skill in operating digital equipment ______________________________

F. Inadequate TTPs ______________________________

G. Lack of training/experience on the MDMP ______________________________

H. Other

OVERALL OBSERVATIONS

25. Did you observe any mission planning errors or oversights that were important enough to reduce the likelihood of a fully successful mission outcome?
    [ ] No
    [ ] Yes
    If yes, describe each error or oversight that you observed and the staff member(s) who made the error or oversight. ____
    ____
    ____
    ____
    ____

26. Did you observe any evidence that increased automation is needed to enable staff members to perform some tasks with sufficient accuracy, comprehensiveness, or timeliness?
    [ ] No
    [ ] Yes
    If yes, describe the task(s) for which you think increased automation is needed. ______
    ____
    ____
    ____
    ____

27. Did you observe any evidence that there is a need to add a staff member to the battalion battle staff whose sole responsibility is to manage the flow of information in a digital TOC during mission planning?
    [ ] No
    [ ] Yes
    If yes, explain the reasons why you think an information manager is needed during mission planning. ____
    ____
    ____
    ____
    ____

28. Did you observe any evidence that one or more member of the battle staff lacked the prior training that was needed to perform his/her tasks during mission planning?
    [ ] No
    [ ] Yes
    If yes, identify the staff member whose prior training was inadequate and the task(s) that were influenced by the training deficiency. ____
    ____
    ____
    ____
    ____

APPENDIX D

Mission Execution Observations

Observer's Name ____________________ Date ________ Mission Number ________ Observation Station ________

COMMUNICATION EVENTS

Time	From	To	Request	Respond	Push	Sit. Update	Coord.	Message Content

OTHER PROBLEMS/EVENTS

Workload	Sit. Aware.	Decision Pt	Decision E	Skill Def.	Other	Staff Member/Notes

COMMUNICATION EVENTS

Time	From	To	Request	Respond	Push	Sit. Update	Coord.	Message Content

OTHER PROBLEMS/EVENTS

Workload	Sit. Aware.	Decision P	Decision E	Skill Def.	Other	Staff Member/Notes

DEFINITION OF TERMS FOR MISSION EXECUTION OBSERVATION FORM

ITEM	COMMENTS
Observer's Name	None
Date	None
Mission Number	The missions will be numbered consecutively beginning with the first mission following the rehearsal or practice missions (if any).
Observation Station	Station 1 will observe - S-2 - JSTARS Operator (AS-2) - UAV Operator (S-2 NCO) Station 2 will observe - -ASAS Operator (S-2 NCO) - Battle Captain - Assistant Battle Captain - MCS/P Operator (S-3 NCO) Station 3 will observe - S-3 (when present in TOC) - AS-3 (?) - Printer Operator (S-3 NCO) - FAADEO Operator (ADO) - AMDWS Operator (ADO NCO) Station 4 will observe - Battalion Commander (when present) - Deputy Commander - FSO - AFATDS Operator Station 5 will serve as backup for other four stations
Time	Enter the time elapsed since the mission started. Record the time of all communication events and all "other problems/events" that are discussed below.
From	Enter the identification code of the battle staff member who initiated the communication event. Use the following codes. C = Commander X = XO (Deputy Commander) B = Battle Captain AB = Assistant Battle Captain 2 = S-2 J = JSTARS Operator (Assistant S-2) U = UAV Operator (S-2 NCO) A = ASAS Operator (S-2 NCO) 3 = S-3 M = MCS/P

P = Printer Operator (S-3 NCO)
F = FSO
AF = AFATDS Operator
FA = FAADEO Operator (ADO)
AM = AMDWS Operator (ADO NCO)

To	Enter the identification code of the battle staff member who was the main recipient of the information. Use the same codes as listed above.
Request	Check the corresponding cell if the communication event was a request for information. That is, the communication event consists of one staff member requesting information from another staff member.
Respond	Check the corresponding cell if the communication event was a response to a prior request for information.
Push	Check the corresponding cell if one staff member conveys information to another staff member without being requested (explicitly) to do so.
Situation Update	Check the corresponding cell if the communication event is a general situation update provided by one staff member for the benefit of all or most of the other staff members.
Coordinate	Check the corresponding cell if the purpose of the communication event is to coordinate the activities of the battle staff members or the activities external persons/units.
Message Content	As briefly as possible, describe the content of the message.
Workload	Check the corresponding cell if a staff member's workload is considered excessive.
Sit. Awareness	Check the corresponding cell if a staff member clearly lacks a sufficient level of situation awareness. Interpretation of a staff member's verbal responses and overt actions is the only way to assess situation awareness through casual observation.
Decision Pt[1]	Check the corresponding cell if the situation requires a staff member to make a decision.
Decision E[2]	Check the corresponding cell if a decision made by a staff member has an adverse effect on the mission outcome. Decision error may not apparent at the time the decision is made but become obvious as the mission proceeds.
Skill Def.[3]	Check the corresponding cell if you observe evidence that a staff member lacks the skills needed to perform his/her assigned job.
Other	Check the corresponding cell if you observe other events that may be important to the objectives of the study. These events may simply be events that needed to be discussed and/or clarified during the AAR.

[1] Pt. = point
[2] E = error
[3] Def = deficiency

Staff Member/Notes	In the space provided in this column, record the staff member who experienced the problem/event and make the notes you need to jog your memory about the event that occurred.
Page	In the space provided, number sequentially all of the pages used during a mission execution exercise.

APPENDIX E

Battle Staff Training Effectiveness Survey

We would like your input regarding the use of the ATCCS suite and virtual simulations as instructional media for battle staff training. Please respond to the items below by indicating the degree to which you agree with the statement. For each item, mark the box that corresponds to your level of agreement. Although you are certainly fatigued by this point and want only to get out of here, please take a moment to make comments or suggestions, positive or negative, at the end of the form.

Thank you for all your effort. The work you have done this week will help the Army to be better prepared for war.

1. I feel I gained substantial benefit from the exercise.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

2. I know more now than I did before the exercise.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

3. The ATCCS exercise was interesting and enjoyable.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

4. The exercise exceeded my expectations.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

5. The ATCCS environment was well designed.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

6. Observers/Controllers provided beneficial instruction.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

7. The skills required in the ATCCS exercise are important during field exercises.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

8. The feedback I received during this exercise was very important.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

9. The ATCCS suite provides significant improvement in information exchange.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

10. The ATCCS scenarios well simulated actual battlefield engagements.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

11. I intend to apply what I learned here in field assignments.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

12. The ATCCS exercise was a useful learning experience.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

13. I believe that this experience will help me perform better as a staff officer.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

14. I intend to use what I learned during this exercise in future assignments.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

15. I was well prepared for this training exercise.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

16. This training helped improve my leadership skills.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

17. The digitized TOC enhances battalion staff capabilities.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

18. The exchange of information through digitized communication was easy.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

19. The observers provided good analyses of the battalion staff performance.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

20. Planning and executing missions is easier in a digitized TOC.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

21. The ATCCS lasted the right amount of time to be useful.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

22. I acquired new skills from the ATCCS exercise.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

23. I would like to participate in other similar exercises.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

24. I learned a great deal during the ATCCS exercise.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

25. This training will have a positive effect on my future performance.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

26. This was a good learning experience for me.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

27. Mission planning is faster in the digitized TOC.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

28. I enjoyed myself during this exercise.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

29. I have a better level of ability as a staff officer because of this exercise.

☐ Strongly Disagree ☐ Mildly Disagree ☐ Neutral ☐ Mildly Disagree ☐ Strongly Disagree

30. The AAR process was a useful learning tool.

☐	☐	☐	☐	☐
Strongly Disagree	Mildly Disagree	Neutral	Mildly Disagree	Strongly Disagree

31. Your comments and suggestions regarding the exercise:

ORIGINAL SCALES FOR TRAINING EFFECTIVE QUESTIONNAIRE

Scale A: Learning

- I learned a great deal during the ATCCS exercise.
- I know more now than I did before the exercise.
- This was a good learning experience for me.
- I acquired new skills from the ATCCS exercise.
- I have a better level of ability as a staff officer because of this exercise.

Scale B: Exercise conduct

- I was well prepared for this training exercise.
- The ATCCS environment was well-designed.
- The ATCCS scenarios well simulated actual battlefield engagements.
- The skills required in the ATCCS exercise are important during field exercises.
- The ATCCS lasted the right amount of time to be useful.

Scale C: Future application

- I intend to apply what I learned here in field assignments.
- I believe that this experience will help me perform better as a staff officer.
- This training will have a positive effect on my future performance.
- I intend to use what I learned during this exercise in future assignments.
- This training helped improve my leadership skills.

Scale D: Digital system utility

- The exchange of information through digitized communication was easy.
- The digitized TOC enhances battalion staff capabilities.
- Planning and executing missions is easier in a digitized TOC.
- The ATCCS suite provides significant improvement in information exchange.
- Mission planning is faster in the digitzed TOC.

Scale E: Instructional feedback

- The feedback I received during this exercise was very important.
- The AAR process was a useful learning tool.
- The observers provided good analyses of the battalion staff performance.
- Observer / Controllers provided beneficial instruction.
- The ATCCS exercise was a useful leraning experience.

Scale F: Enjoyment

- I enjoyed myself during this exercise.
- This exercise exceeded my expectations.
- I would like to participate in other similar exercises.
- I feel I gained substantial benefit from the exercise.
- The ATCCS exercise was interesting and enjoyable.

APPENDIX F

Mission Planning Observations: Participants Who Performed the MDMP Substeps

Notes on The Interpretation of the Following Data Tables

1. The numbers in the cells refer to dates on which mission planning was observed (2 = March 2, 4 = March 4, 5 = March 5). Mission 1 was planned on March 2, Mission 2 was planned on March 4, and Mission 3 was planned on March 5.
2. A numbers in a cell indicates that the corresponding battle staff member participated in the corresponding substep on the dates indicated. The cell entry "2, 5" indicates that the corresponding substep was performed by the corresponding battle staff member on both March 2 (Mission 1) and March 5 (Mission 3).
3. A shaded cell indicates the battle staff members ordinarily participate in the performance of the corresponding substep (as specified in FM 100-5).
4. The substep numbers are arbitrary.

	BATTLE STAFF MEMBER							
SUBSTEPS IN MDMP (RECEIVE THE MISSION)	**CDR**	**XO**	**S-1**	**S-2**	**S-3**	**S-4**	**FSO**	**ADO**
1. Issue a WO to staff personnel					2,5			
2. Determine initial timelines		2			5			
3. Issue initial commander's guidance	2	5						
3a. Receive initial commander's guidance		2		2	2		2	
4. Issue a WO to subordinates and support units		5			2,5			

	BATTLE STAFF MEMBER							
SUBSTEPS IN MDMP (EVALUATE THE MISSION)	**CDR**	**XO**	**S-1**	**S-2**	**S-3**	**S-4**	**FSO**	**ADO**
1. Review the higher headquarters order					2,5			
1a. Determine staff priorities/stds & coordinate mission anal.		2,5			5			
1b. Review known enemy and friendly situations				2	2			
2. Conduct initial IPB				5	2			
3. Determine specified, implied, and essential tasks		5			2,5			
4. Review available assets		2			2,5			
5. Determine constraints		5			2,5			
5a. Determine constraints		5			2,5			
5b. Determine and maintain the status of personnel		5			5			
5c. Determine and maintain the logistic status		5			5			
5d. Determine FS asset allocation status, et.al							5	
5e Determine air defense warning status					2		5	
6. Identify critical facts and assumptions		2,5		5	2			
7. Conduct risk assessment		2,5		5				
9. Determine initial commander's critical information reqts.					2,5			
9a. Forecast and examine personnel reqts previously identified			2					
9b. Identify areas for which the cdr. Is responsible					2,5			
9c. Compare higher hqs order FA data to AFATDS data							2,5	
9d. Determine status of fire units that are providing protection					2			
9e. Identify friendly vulnerabilities and limitations		5			2,5			
9f. Determine capabilities of available FA assets and ammo							2,5	
10. Determine the initial reconnaissance plan		5			2,5			
10a. Coordinate external logistics support						2.5		
10b. Refine timelines		2,5			5			
10c Determine liaison requirements					2,5			

	CDR	XO	S-1	S-2	S-3	S-4	FSO	ADO
10d Identify users and uses of airspace					2,5			
10e Identify A2C2 measures imposed by higher hqs, et.al.					2,5			
11. Plan use of available time					2,5			
12. Write the restated mission		2			2,5			
13. Conduct a mission analysis briefing		2,5	2,5	2,5	2,5	2,5	2,5	
13a. Receive mission analysis briefing	2	5						
14. Approve the restated mission	2	5						
15. Develop initial commander's intent	2	5			5			
15a. Receive commander's intent and planning guidance		2,5	2,5	2,5	2,5	2,5	2,5	
16. Issue the commander's guidance	2.5							
17. Issue a WO to subordinate and supporting units					2,5			
18. Review facts and assumptions	2	2,5	2	2	2,5	2	2	

	BATTLE STAFF MEMBER							
SUBSTEPS IN MDMP (DEVELOP THE COA)	**CDR**	**XO**	**S-1**	**S-2**	**S-3**	**S-4**	**FSO**	**ADO**
0. Conduct direct coordination with supported ground cdrs.	2	5						
1. Analyze relative combat power		5			4,5			
1a. Define the most probable and dangerous enemy COAs		5		2	2,5			
2. Generate options		2,5		2	2,5			
3. Array initial forces		5		2	2,5			
4. Develop a scheme of maneuver		5		2	5			
4a. Describe effects of the AO and enemy situation on COA				2,5				
5. Assign Headquarters					5			
5a. Conduct COA briefing								
5b. Receive COA briefing								
6. Prepare COA statements and sketches		5		5	5	5		

	BATTLE STAFF MEMBER							
SUBSTEPS IN MDMP (EVALUATE THE COA)	**CDR**	**XO**	**S-1**	**S-2**	**S-3**	**S-4**	**FSO**	**ADO**
1. Gather the tools		2,4,5	2	3	2,5	2	2	
2. List all friendly forces		4,5			2,4,5			
3. List assumptions		5			2,4			
4. List known critical events and decision points		5			4			
5. Determine evaluation criteria				2	2,4			
6. Select the war-game method		4,5			4			
7. Select a method to record and display results					2			
8. War game the battle and assess the results	2,4	2,4	2,4	2,4	2,4	2,4	2,4	
8a. Refine COA		2,4	2,4	2,4	2,4	2,4	2,4	
8b. Identify key or decisive terrain and determine how to use it					2,4			
8c. Determine task organization					2			
8d. Identify tasks the unit must retain and tasks to be assigned		2			2,4			
8e. Develop a synchronization matrix	4	4,5	4	4	2,4	4	4	
8f. Develop decision support template	2,4	2,4,5	2,4	2,4	2,4,5	2,4	2,4	
8g. Estimate the duration of each critical event operation	4	2,5	2	2	2,4,5	2	2	
8h. Identify location and commitment of the reserve				2,4				
8i. Identify the location of the CDR's and unit's CPs				2,4				
8j. Identify additional critical events			2	2,4				
8k. Determine requirements for deception and surprise	4	4	4	2,4	4	4	4	
8l. Determine C2 requirements				2,4				
8m. Determine timing of force concentration and attack			2,4	2,4				
8n. Determine movement times and tables				2,4				
8o. Develop SEAD plan			2	2,4				
8p. Integrate the targeting process				2			2,4	
8q. Identify risks, determine acceptable risks, & risk avoidance				2,4				
8r. Project the percentage of total enemy forces defeated			2					
8s. Identify likely times and areas for enemy use of WMD			2					
8t. Refine CCIR and incorporate into the R&S plan/grpahics			2					

8u. Identify and/or confirm the locations of decision points		5		2,4,5	5			
8v. Develop the intelligence collection and dissemination plan				2,4,5	4,5			
8w. Integrate the targeting process		5			5		2,4	
8x. Develop Scheme of fires		5			5		2	
8y. Develop execution matrix		2,5		2	5		5	
8z. Develop target template/target list worksheet		5			5		2	
8aa Develop fire support overlay		5			5		2	
8ab Allocate combat, Cs, and CSS assets to subordinate cdrs.		5	2		5	2		
8ac Develop AD plans/graphics		5			5			
8ad Develop CSS plans/graphics		5			5			
8ae Identify additional requirements for CS		5			5	2		
8af Develop CSS plans/graphics		5			5			
8ag Identify/analyze/evaluate strengths/weaknesses of COA		2,5		5	5			
8ah Conduct war game briefing								
8ai Receive war game briefing								
8aj Assess and manage risk	2	5						

	BATTLE STAFF MEMBER							
SUBSTEPS IN MDMP (COMPARE THE COA)	**CDR**	**XO**	**S-1**	**S-2**	**S-3**	**S-4**	**FSO**	**ADO**
1. Analyze and evaluate the advantages and disadvantages		2,5			2,5	2		
1a. Determine and consolidate all airspace uses/users/conflicts		2.5			2.5			
2. Present each staff section's findings		2,5			2,5			
3.Compare COA utilizing previously defined evaluation criteria		2,5			2,5			
3a. Conduct COA decision brief		2,5	2	2	2,5	2	2	
3b Receive COA decision briefing	2,5							
4. Select recommended COA	2,5							

	BATTLE STAFF MEMBER							
SUBSTEPS IN MDMP (APPROVE THE COA)	**CDR**	**XO**	**S-1**	**S-2**	**S-3**	**S-4**	**FSO**	**ADO**
1. Conduct commander's decision brief		2		2	2,5			
2. Approve COA	2,5	5						
3. Issue commander's guidance	2,5	5						
3a. Repeat portions of steps 3-5, as necessary								
4. Issue WO to subordinate and supporting units		5			2			

APPENDIX G

Acronyms and Abbreviations

1/145	First Battalion of the 145th Aviation Regiment, First Aviation Brigade
4ID	Fourth Infantry Division
AAR	After Action Review
ABC	Assistant Battle Captain
ABCS	Army Battle Command System
ABM	Air Battle Management
ADA	Air Defense Artillery
ADO	Air Defense Officer
AFATDS	Advanced Artillery Tactical Data System
AHB	Attack Helicopter Battalion
ALOC	Administrative and Logistics Operations Center
AMBL	Air Maneuver Battle Lab
AMDW/S	Air and Missile Defense Workstation
AMPS	Aviation Mission Planning System
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
AS2	Assistant S2
AS3	Assistant S3
ASAS	All Source Analysis System
ASTi	Advanced Simulation Technology, Inc.
ATACMS	Army Tactical Missile System
ATCCS	Army Tactical Command and Control System

ATHS	Automated Target Handover System
AVOAC	Aviation Officers Advanced Course
AVTB	Army Aviation Test Bed
AWSC	Aviation Warfighting Simulation Center
BADD	Battlefield Awareness Data Dissemination system
BC	Battle Captain
BFA	Battlefield Functional Area
BPV	Battlefield Planning / Visualization system
BRIL	Baseline Resource Items List
C^4I	Command, Control, Communications, Computers and Intelligence
CAS	Close Air Support
CGF	Computer Generated Forces
CGS	Common Ground Station
CO	Commanding Officer
COA	Course of Action
CSAR	Combat Search and Rescue
CSS	Combat Service Support
CSSCS	Combat Service Support Control System
CTIL	Commander's Tracked Items List
DCD	Directorate of Combat Developments
DIS	Distributed Interactive Simulation

DOTDS	Directorate of Training, Doctrine and Simulation
DP	Decision Point
DST	Decision Support Template
DTSS	Digital Topographical Support System
EAC	Echelons Above Corps
EADSIM	Extended Air Defense Simulation
EO	Engagement Operations
EPLRS	Enhanced Position Location Reporting System
$FAADC^2$	Forward Air Defense Command and Control system
$FAADC^2I$	Forward-Area Air Defense Command, Control and Intelligence
FAADEO	Forward-Area Air Defense Engagement Operations
FAADFO	Forward-Area Air Defense Force Operations
FARP	Forward Area Refueling Point
FBCB2	Force XXI Battle Command Brigade and Below
FLOT	Forward Line of Own Troops
FM	Frequency Modulation
FO	Force Operations
FRAGO	Fragmentary Orders
FRED	Fully Reconfigurable Experimental Device
FSO	Fire Support Officer
FTP	File Transfer Protocol
GCCS-A	Global Command and Control System - Army
GS	General Support

IEW	Intelligence and Electronic Warfare
IMETS	Integrated Meteorological System
INC	Integrated Network Controller
IPB	Intelligence Preparation of the Battlefield
IWEDA	Integrated Weather Effects Decision Aid
JSTARS	Joint Surveillance Target Attack Radar System
LAN	Local Area Network
LOS	Line of Sight
MCOO	Modified Combined Obstacle Overlay
MCS	Maneuver Control System
MCS	Maneuver Control System
MDMP	Military Decision Making Process
MLRS	Multiple Launched Rocket System
ModSAF	Modular Semi-Automated Forces
MSE	Mobile Subscriber Equipment
MTI	Moving Target Indicator
NAI	Named Area of Interest
NCO	Noncommissioned Officer
NDM	Naturalistic Decision Making
NTDR	Near Term Digital Radio
ODCST	Office of the Deputy Chief of Staff for Training
OPCON	Operational Control
OPFOR	Opposing Force

OPORD	Operational Order
PATRIOT	Phased Array Tracking Intercept of the Target missile
PIU	Protocol Interface Unit
PMOS	Primary Military Occupational Specialty
RWS	Remote Workstation
S1	Personnel Officer
S2	Intelligence Officer
S3	Operations and Training Officer
S4	Supply Officer
SIMNET	Simulation Network
SINCGARS	Single Channel Ground Air Radio System
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SSI	Specialty Skill Indicator
STAMIS	Standard Army Management Information System
TAFSIM	Target Acquisition Fire Support Model
TAI	Target Area of Interest
TEL	Threat Transporter-Erector-Launcher missile
TO&E	Table of Organization and Equipment
TOC	Tactical Operations Center
TRADOC	Training and Doctrine Command
TSIU	Tactical Simulation Interface Unit
TSP	Training Support Package

TTP	Tactics, Techniques and Procedures
TUAV	Tactical Unmanned Aerial Vehicle
UAV	Unmanned Aerial Vehicle
USAAVNC	U. S. Army Aviation Center
USMTF	United States Message Text Format
WFD	Warfighting Futures Division, DOTDS
WAN	Wide Area Network
XO	Executive Officer